PRODUCT ENGINEERING

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Not Politics—Just Common Sense

ON THE FOLLOWING pages is given a report of the status of proposed new patent legislation based on opinions and statements gathered through interviews with Congressmen and a former Commissioner of the Patent Office.

It appears that in undertaking to change our patent laws, political Washington has put the cart before the horse. The procedure seems to have been about as follows: Someone got the idea that large corporations are getting too much protection from patent laws, hence the patent laws must be changed. The next step was to introduce an absurd bill, have it printed and hold hearings. Industrialists, manufacturers, inventors and patent attorneys were invited to testify against the bill. Those steering the bill do not seem to be interested in any testimony on the merits of the bill, if it has any. After hearing for eight or nine days opposition of the bill, the sub-committee holding the hearings recessed indefinitely.

A logical procedure would have been to first determine if there is any real need for a revision of our patent laws. Had this been the first step it is safe to say that it would have been discovered that the charge of "suppressing patents" is a figment of the imagination. In the volumes of testimony taken at hearings on previous bills of this nature, only one doubtful instance of a genuine suppression of a patent to the disadvantage of society was uncovered. And that patent had been suppressed because the manufacturer considered that the device had not been perfected sufficiently.

In fact, suppression of a patent for a limited period of time might be a good thing in some instances. Farmers are paid bonuses for crop suppression. Why not pay a patent owner a bonus to limit the manufacture of a great labor saving machine, such as the Rust cotton picker is claimed to be. Would this not prevent a major disturbance in the labor market, just as limited cotton planting avoids a major disturbance in the cotton market? This sounds ridiculous, but it is a fact that under N.R.A. coal mines were restricted in the purchase and use of labor saving machinery. Which all goes to show that there are two sides to this question of suppressing patents.

As to unduly high prices charged for patented products, there are so many evident arguments favoring the present status that it is a waste of space to talk about it.

No reasons other than "suppression" and "high prices" have been advanced for this change in our patent laws. These two catch-words have a strong political flavor, especially when the charge is made against "large corporations." And unless the engineering and patent law fraternities convince the public that this whole patent legislation procedure is fallacious, we might wake up to find ourselves saddled with new patent laws that will make invention and discovery unprofitable.

Both socially and economically, the proposed patent legislation or any patent legislation of the same nature is unsound. The immediate sufferers would be engineering designers, research workers and inventors. The ultimate losers would be everybody. It would be a step in the wrong direction. And after all, it is terriby silly to risk the whole future of American industrial progress even if one or two inventions in several hundred thousand are improperly exploited. Let good enough alone. A 999 batting average is considered excellent.

Harris & Ewing

Congress assembled—Will a session in the near future pass legislation that will affect patent protection?

H. R. 10068

A Bill to Provide for Compulsory Licensing of Patents

G. F. NORDENHOLT, *EDITOR*

On the premise that the public interest will be advanced by a curtailment of the rights and privileges granted by patents, Washington law makers are attempting to devise the necessary legislation. This article reviews the situation, propounds a few questions and reports interviews with members of the House Committee on Patents and with others

ON MARCH 29, 1938, Mr. McFarlane of the House of Representatives introduced the bill, known as H. R. 10068, which was referred to the Committee of Patents and ordered to be printed. H. R. 10068 reads as follows:

To provide for compulsory licensing of patents.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That section 35 of the Revised Statutes is amended to read as follows:

"SAME; OATH OF APPLICANT.—The applicant shall make oath that he does verily believe himself to be the original and first inventor or discoverer of the art, machine, manufacture, composition, or improvement, or of the variety of plant, for which he solicits a patent; that he does not know and does not believe that the same was ever before known or used; and shall state of what country he is a citizen, and all owners of patents whose term has not expired and all applications pending and all applications hereafter filed shall file an itemized statement setting forth the time he has devoted to the development of the patent, and all expenses incurred, as well as the intrinsic value of his patent. Such oath may be made before any person within the United States authorized by law to administer oaths, or, when the applicant resides in a foreign country, before any Minister, Charge D'Affaires, or consul, holding commission under the Government of the United States, or before any notary public, judge, or magistrate having an official seal and authorized to administer oaths in the foreign country in which the applicant may be, whose authority shall be proved by certificate of a diplomatic or consular officer of the United States."

SEC. 2. That section 40 of the Revised Statutes is amended to read as follows:

"Every patent shall contain a short title or description of the invention or discovery, correctly indicating its nature and design, and a grant to the patentee, his heirs or assigns, for the term of seventeen years of the exclusive right to a royalty through the licensing of the invention or discovery or to vend the invention or discovery (including in the case of a plant patent, the exclusive right to asexually reproduce the plant) throughout the United States and

Territories thereof, referring to the specification for the particulars thereof. A copy of the specification and drawings shall be annexed to the patent and be a part thereof. For the first five years of the patent grant the inventor shall have the exclusive right to make, use and vend, in addition to the rights enumerated above, the invention or discovery."

APPLICATION FOR A LICENSE

SEC. 3. At any time after the expiration of five years from the date of issuance of a patent where satisfactory evidence is submitted showing that a patent is not being used or that the domestic supply is insufficient to satisfy the public demand or that unfair prices or trade practices prevail, any person may file with the Commissioner of Patents an application for a license under said patent, setting forth under oath his reasons why such license should be granted. The applicant shall file with the Commissioner of Patents—

1. Evidence that the applicant is an interested party, financially responsible, and able to manufacture such patent.

2. A statement that the public interest will be advanced by issuing to him a compulsory license for such patent.

3. An offer which shall include specific terms, conditions, and royalties under which the applicant proposes to use such a patent, if his application for such license is granted.

NOTICE

SEC. 4 (1) If the Commissioner of Patents determines that the applicant is an interested party, financially responsible, and able to manufacture such patent; and

(2) That the public interest will be served by the granting of a compulsory license, he shall publish a notice of the application and his decision in the Official Gazette of the United States Patent Office for at least four consecutive weekly issues. In such notice he shall specify that any person having any right, title, or interest in such patent may upon application be permitted to intervene to show cause why such license should not be issued to the applicant. A copy of such notice shall be served by registered mail upon the patentee and upon any attorney recorded in the Patent Office as having last represented such patentee in respect of obtaining the grant of such patent.

HEARING

SEC. 5 (a) The Commissioner of Patents shall, in the notice provided for in section 4, specify a time (not later than thirty days after the date of the last publication authorized in section 4) and place for a hearing in respect to such application.

(b) At such time the applicant, the patentee, and any other person claiming any right, title, or interest in or to such patent may appear and under oath file answer and be heard in respect to such application.

(c) If within thirty days after date of such last publication the patentee or any person claiming any right, title, or interest in such patent fails to appear to show cause why such license should not be granted, or if such patentee or attorney fails to answer the notice served upon him by the Commissioner of Patents, the latter may grant a compulsory license to any applicant.

GRANTING OF LICENSE

SEC. 6. At the hearing provided for in section 5 to determine whether such license should be granted if the applicant, and the Commissioner of Patents shall decide that such a license should be granted under the application, such license shall be granted for a term of years not to exceed the duration of the life of the patent.

APPEALS

SEC. 7. If the patentee should consider the decision of the Commissioner of Patents unfair with respect to the amount of royalties or any other conditions he may set under this Act, then the patentee shall have the right of appeal within thirty days thereafter to the United States Court of Customs and Patent Appeals, or to the United States district court of the residence of the owner of the patent.

The above bill had been preceded by the Bill H. R. 9259 which was introduced by Mr. McFarlane on January 31 and referred to the Committee on Patents. The two bills are similar, the principal difference being that the earlier bill specified that "at any time after the expiration of three years from the date of issuance of a patent, any person may file with the Commissioner of Patents an application for a license under said patent." The later Bill H. R. 10068 specifies, "For the first five years of the patent grant the inventor shall have the exclusive right to make, use and vend, . . ." Other than that, the two bills are practically alike.

The House Committee on Patents, William I. Sirovich of New York, Chairman, appointed a sub-committee to hold hearings on these bills. Thomas O'Malley of Wisconsin is the chairman of this sub-committee of five and for eight or nine days the sub-committee held hearings, inviting those opposed to the bill to present their arguments and evidence. These hearings were to be followed by hearings at which proponents of the bill were to present their arguments and evidence in favor of it. However, after closing the hearings for the opponents of the bill, the sub-committee recessed indefinitely.

As matters now stand, there is no possibility of this bill coming before the present session of Congress. At the earliest, it will be put before Congress next January. Furthermore, there is every indication that the bill will never come before Congress. "It is crazy" said one member of the main committee. And interviews with various other members of the committee forces one to the conclusion that the bill will be killed in committee.

If such is the case, why talk about it? Because there is every indication that those in favor of a revision of the patent laws will use the data and information uncovered at the hearings on the present patent bills to create a new patent bill designed to "Eliminate the evils perpetrated under the present patent laws and a bill that will be a real benefit to society." Some sort of a patent bill of such a nature is admittedly favored by the administration.

Bills for the compulsory licensing of patents are not new. To mention only a few, there were several Oldfield Bills, among them H. R. 15989 introduced in 1914; the Paige Bill, H. R. 19187; Stanley Bill S. 3410; the King Bill S. 3474 in 1926, S. 203 in 1929, S. 22 in 1931, S. 290 in 1933 and Bill S. 383 in 1935. None of them ever came before Congress. They are mentioned here because much of the testimony recorded at the hearings on these bills is applicable to the present bill and any other bill on this subject that may come up for consideration.

Naturally, the first question that arises is "What are the present evils and abuses of the patent laws that might be abolished by changes in the present law?" Unfortunately the hearings on this bill for those in favor of it have not been held and probably will not be held. But the following evils and abuses under the present patent laws are either stated or implied:

1. Larger corporations maintain high prices.
2. Advantages of the progress of science are withheld from the public.
3. Patents owned by larger corporations are sometimes suppressed.
4. Unfair prices or trade practices prevail.
5. The supply of patented products is sometimes restricted to a point insufficient to satisfy the public demand.

Changing Views on Patents

Because the McFarlane bill never got to the point of being debated before the House, it is not known what arguments additional to the above might have been brought up in favor of a change in the patent law. Nor have the proponents for the bill advanced any specific cases or evidence of abuse of the present patent law. However, one member of the House Committee on patents explained to me the changing views on patent laws.

"Whereas formerly individuals invented and patented new products and devices," explained this Congressman, "today about 80 per cent of the patents at the time of issue are assigned to a corporation. Of the remaining 20 per cent, probably more than 90 per cent of them are 'crackpot' ideas, that have no possible commercial value. Therefore, whereas the patent laws as originally drawn were intended to protect the individual inventor, they are now primarily protecting the corporations that develop and invent new things in their research laboratories.

"Of course, any legislation that would make it unprofitable to operate a research laboratory would be disastrous. I think we all recognize this. On the

other hand, the public interest can often be served best if the discoveries and inventions coming from the research laboratories of one company are made available by licensing agreement to all other manufacturers in that field. I am not saying that this is my personal opinion, but I am merely giving you an indication of the kind of thinking that is going on with reference to this problem of patent laws.

"In fact, we might attribute a great deal of the progress of the automobile industry and its benefits to the public to the system of inter-licensing of patents among all the manufacturers in that field except Ford. If this has worked out so well in that particular industry, why is it not good for all industries?

"In fact, in view of the extremely high plateau that has been reached in science and engineering, it is impossible for any one or any group to really invent something new or useful without taking advantage of the inventions and discoveries of others. And in many instances, discoveries and inventions which eventually lead to a patent taken out by an individual for a corporation, are initially inventions and discoveries made in a government research laboratory or as the result of experimental work that is done at the expense of the government. The aeronautical industry is a striking example of this."

Making Charges Specific

I wish to emphasize that the House Patent Committee member who expressed these views made it clear that they were not his own personal views but that he was explaining one of the prevalent viewpoints on the patent question.

It is extremely regrettable that the Congressmen or government officials who are sponsoring legislation looking toward a revision of the patent laws did not preface the introduction of the legislation with a bill of particulars indicting the present patent system. The bald statements that the present system is not working in the public interest and that the patent privileges granted are being abused are not sufficient. It is hardly possible for anyone to offer constructive criticisms and suggestions for the improvement of the present patent laws unless the specific evils and their magnitude claimed under the present system are stated specifically. Too often the attempted cure brings with it a whole new flock of evils that are more destructive than the cure is constructive.

One evil or abuse that was pointed out by one of the House Patent Committee members had to do with the relations between individual inventors and patent attorneys, but not with patent abuses themselves. According to him, any individual with an inferiority complex, having failed to achieve fame, glory or financial success, seeks a short cut to this goal. Inventing something and getting a patent seems to offer the desired short cut. He invents a perfectly worthless "do-funny," takes it to a patent attorney and procures a patent. And when the transaction is completed, the inventor has a worthless piece of paper with a government seal and the patent attorney has added a few hundred dollars to his bank account. This is one evil, it was pointed out to me, which might be largely abolished by a revision of the present patent law. We give this to our readers, not as a recommendation, but for their comments.

A great number of Washington press correspondents freely expressed the opinion that the McFarlane bills were introduced to establish the nature of the objections to compulsory licensing. With these objections established a new bill will be drawn up, in the opinion of men "in-the-know," based on the suppositions that (1) the public is the rightful claimant of the creative work of the individuals to the extent that the patentee has no right to withhold an invention which might contribute to the welfare and progress of the people; (2) the present patent laws grant monopolies that are inconsistent with the present day conceptions of economic equality and legislations pertaining to monopolies; (3) large corporations, some holding thousands of patents, a majority of them, dormant, constitute a menace to technological progress in that these corporations have no more right to withhold these creative works from the public than has the inventor.

We will not bore our readers with recounting the objections to these bills. Suffice to say the "Report of the American Patent Law Association opposing the McFarlane Bill H. R. 9259," copies of which can be procured from the American Patent Law Association, 898 National Press Bldg., Washington, D.C., gives a presentation of the objections.

With respect to H. R. 10068,, numerous questions arise. To "file an itemized statement setting forth the time he (the inventor) has devoted to the development of the patent, and all expenses incurred, as well as the intrinsic value of the patent" is usually a practical impossibility. An invention is a creation of the mind and in many instances the inventor's or scientist's mind is on his problem twenty-four hours a day. He even dreams it. And how is the time required to gain the knowledge to be able to make the invention to be calculated? And what has the "intrinsic" value got to do with it? Intrinsic means, according to Webster, "essential; inherent; not merely apparent or accidental; that which is indispensable to its being what it is; real; true." No human being can make even a reasonable estimate of the intrinsic (real) value of a patent because it cannot be expressed in dollars. Under certain patent laws the dollar value of any patent would be zero. Some companies appraise the intrinsic value of their patents at millions of dollars; other appraise the total value of all their patents at one dollar.

Bill H. R. 10068 would give the inventor exclusive rights "for the first five years of the patent. . . . ." After that he is compelled to permit licensing if the "patent is not being used or . . . . , the domestic supply is insufficient to satisfy the public demand or that unfair prices or trade practices prevail." The judge and jury will be the Commissioner of Patents, and if the inventor does not like the decision he can appeal to certain courts. I venture to say that unless the inventor had been smart enough to keep the patent pending for a long time, he would not get very far in five years and it would be easy to show that the "domestic supply is insufficient to meet the public demand." And what is an unfair price? No new invention is a "public necessity"—except in the eyes of the inventor perhaps. Therefore, no matter how high the price may be, is it unfair? If the price is too high the public will simply not buy the product.

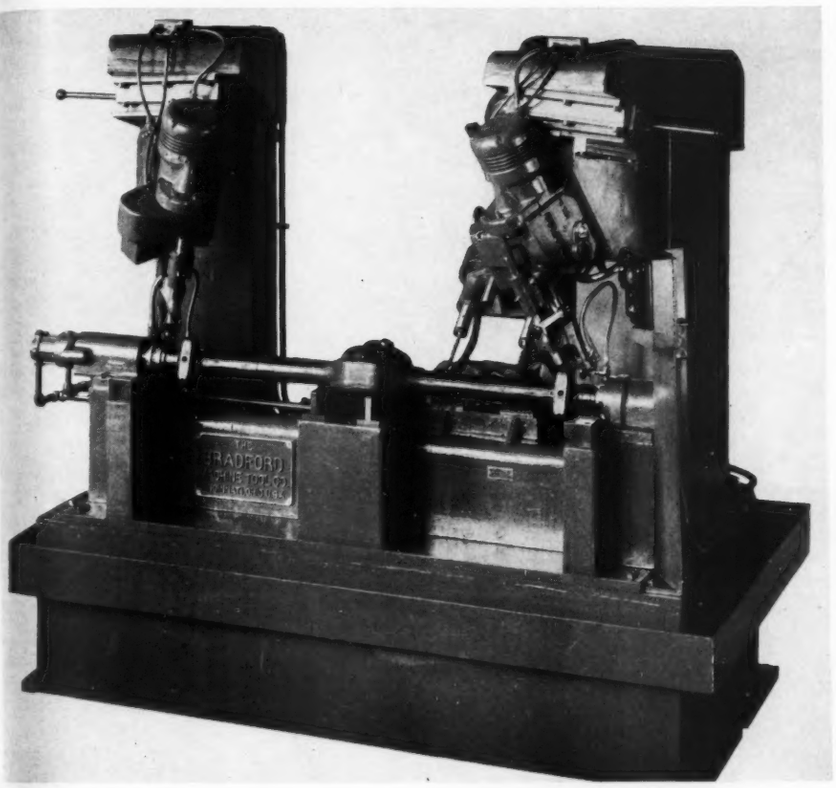
Protect Inventive Genius

England and some of the European countries have compulsory patent licensing laws. But as ex-commissioner of patents Thomas E. Robertson pointed out to me, "Those laws were enacted primarily to compel the manufacture of American inventions in those countries. Under our present patent laws, American inventive genius and scientific progress flourished as in no other country in the world at any time. Morse, Bell, Edison, Steinmetz, Nicola Tesla, Pupin, Baekeland, Millikan, Howe, McCormick and Westinghouse are only a few of the great army of American inventors who have given to the world the most and the greatest inventions and scientific discoveries. Our patent system has unquestionably been the major contributing factor that gave the United States this position of leadership."

Almost all engineers will agree with Mr. Robertson that the world leadership in inventive genius belongs to the United States. All will also agree that there should be no legislation that promises to endanger this leadership. To this end, engineering designers, research workers and inventors should voice their opinions and submit information so that any changes in the patent law that might be made will be sound and enduringly constructive.

Modern Designs

Bradford's Drilling Machine

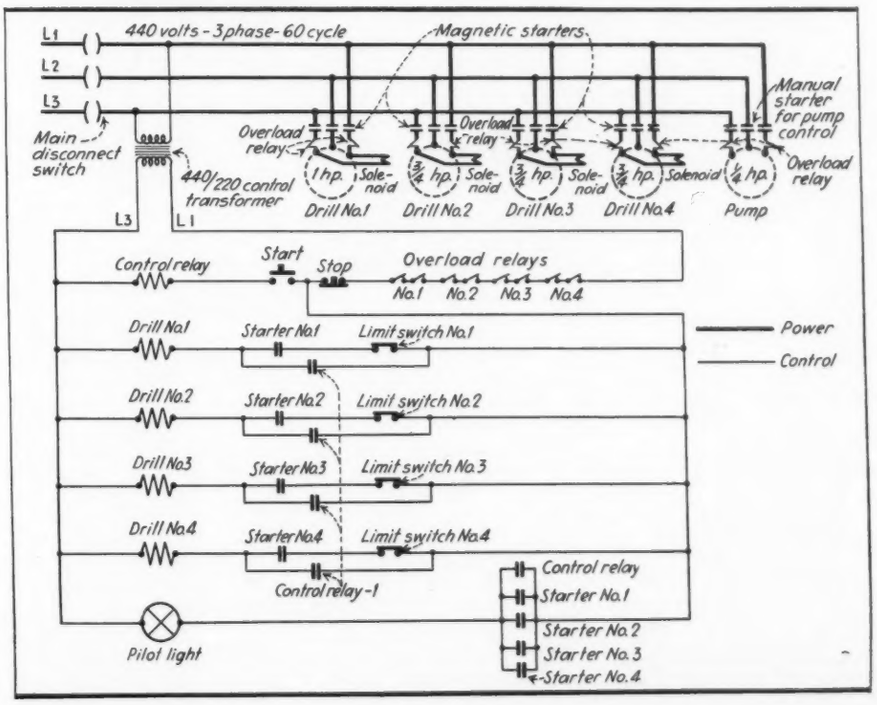


Control and synchronization are completely electrical through built-in limit switches and relays in this Bradford machine, built almost entirely of welded steel, and designed for drilling and chamfering holes in welded steel automobile rear axle housings. Four standard Bradford automatic drilling heads, individually motor driven, are self-contained units with completely automatic cam mechanisms for operation on a pre-determined cycle.

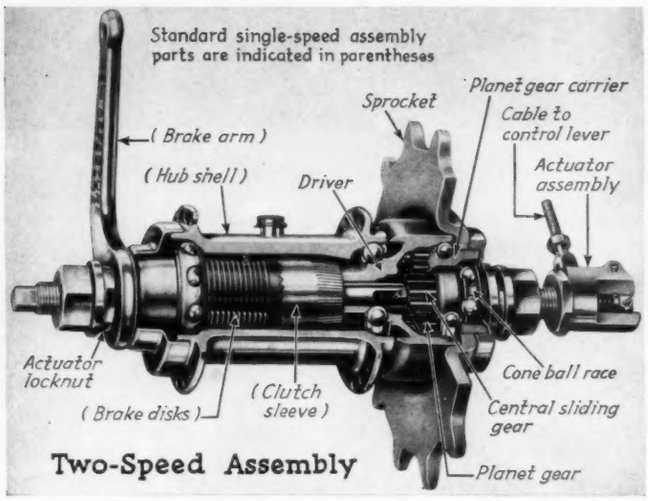
Air valve, mounted on the master control unit, is operated by an intermittent gear mechanism. Upon pressing start button, the valve is opened and compressed air is admitted to one end of the cylinder, and the piston, through levers and toggles, actuates plugs at each end of the fixture, locating and clamping it. These plugs are adjustable and removable for adopting the fixture to other housing sizes. After the drill cycle and return, a trip dog opens a limit switch on each unit, dropping out the magnetic starter and causing the unit to come to a stop. At the same time, the master control actuates the fixture air valve, causing compressed air to enter the other end of the cylinder and unclamp the work.

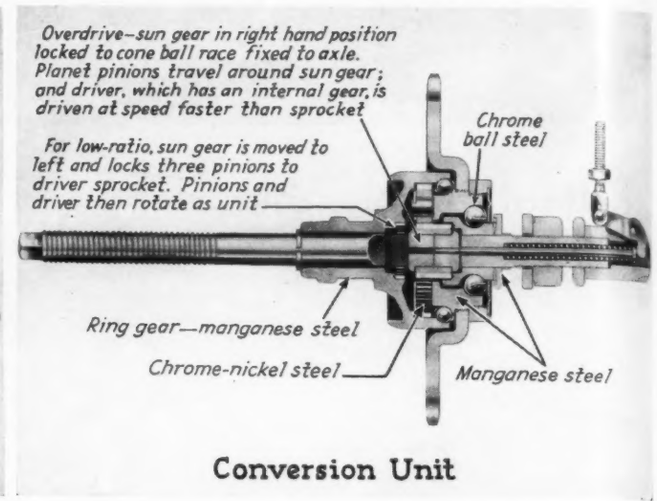
Automatic operation is controlled by a special Allen-Bradley control panel mounted in the rear of the machine base. Each of the drill motors is controlled by a solenoid starter, equipped with double make and break silver contacts which provide overload as well as no voltage protection. The master five pole relay on the panel controls the four solenoid starters. The pump is controlled by a manually operated starter which also has double make and break silver alloy contacts.

Each of the automatic drills on the machine is equipped with an individual clutch operated by a solenoid energized immediately upon the closing of the magnetic starters. The clutch remains closed until the starters are de-energized; solenoids then allow the clutch to open and mechanically disconnect the unit. This eliminates the necessity of providing some type of mechanical brake and allows the motor to coast to a stop without affecting the desired stopping position of the drill upon completion of the drilling cycle.



Modern Designs — Two-Speed Conversion Unit for Bicycles

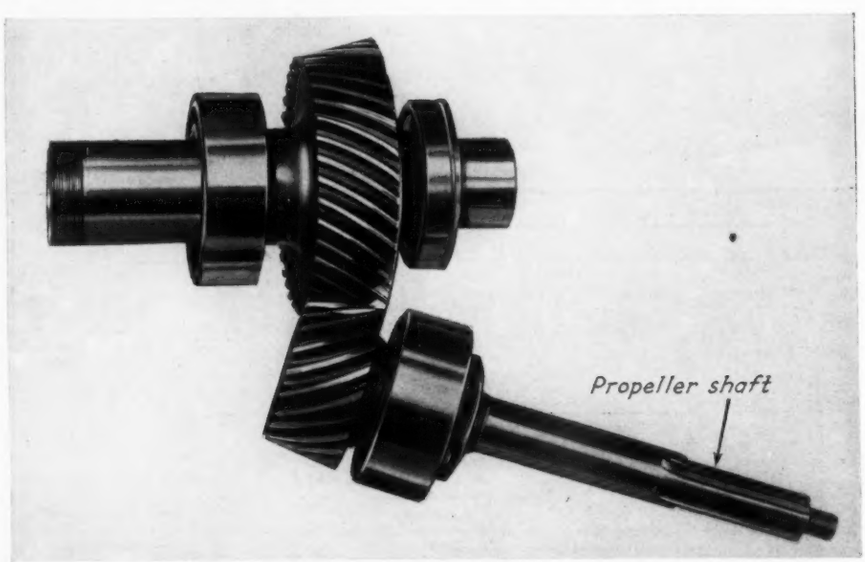


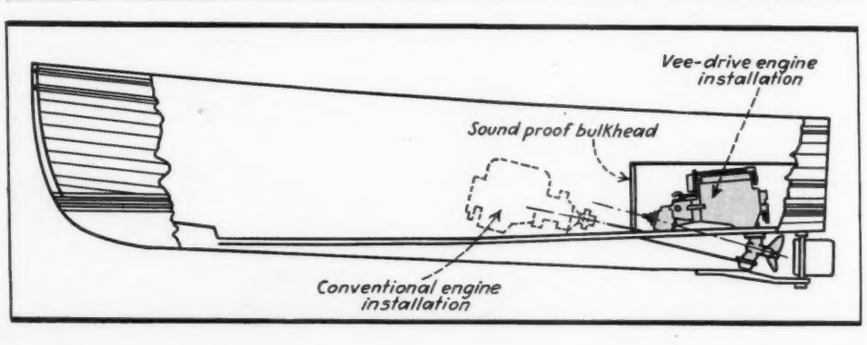

Overdrive—sun gear in right hand position locked to cone ball race fixed to axle. Planet pinions travel around sun gear; and driver, which has an internal gear, is driven at speed faster than sprocket
For low-ratio, sun gear is moved to left and locks three pinions to driver sprocket. Pinions and driver then rotate as unit
Chrome ball steel
Ring gear—manganese steel
Chrome-nickel steel
Manganese steel
Conversion Unit

Ease of Conversion of the conventional single-speed brake mechanism to a two-speed type, without appreciable added weight or number of parts, was the aim of the New Departure engineers in designing this new two-speed conversion unit. It adds only 14 oz. weight in converting the old single-speed brake to a two-speed mechanism, the change being effected by merely replacing the axle and sprocket assembly. All highly stressed parts in this two-speed conversion unit are made of special alloy steels: chrome, chrome-nickel, or chrome-vanadium. Less highly stressed parts are of high strength manganese steel, and the brake arm is of heat-treated carbon steel.

Shifting of the center gear is effected by two keys moving in a slot, held together by a shifting rod within the axle extension. For low gear, the rod is pushed inward against the pressure of a return spring by the cable-operated bell crank at the right. Cable, which shifts drive from low to high, is operated by a lever on the bicycle frame.

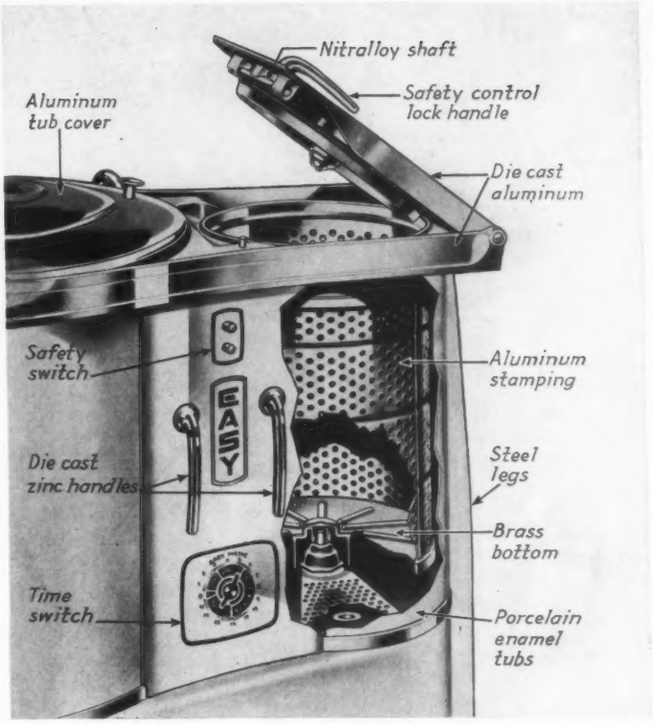
New Chrysler Vee Reduction Drive





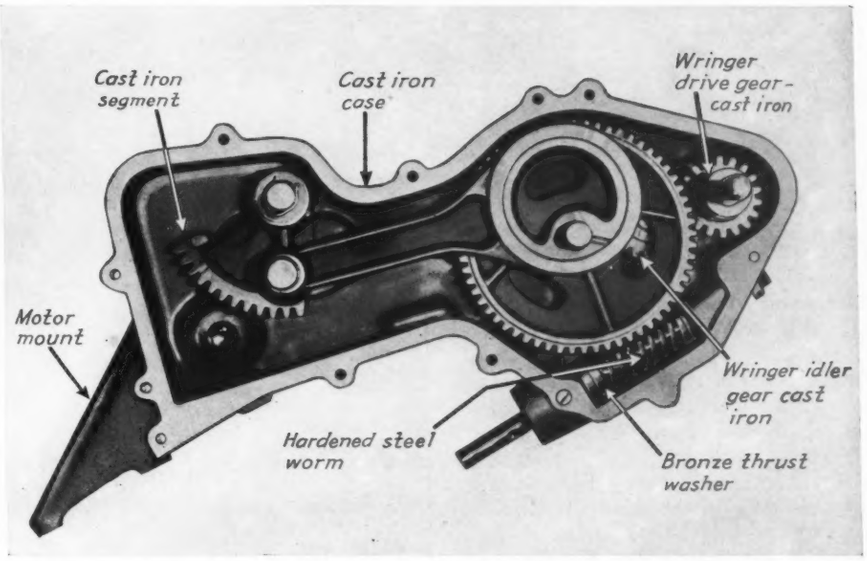
Power plant installation at the rear of the boat, reducing noise and permitting better utilization of cabin space, is made possible with new Chrysler Vee reduction drive unit. Drive has two to one reduction and is built integral with the engine, with the propeller shaft tunneling through the gear box. This permits shortening of propeller shaft to about six feet. No support for the shaft is required between the engine coupling and the strut other than a rubber-mounted stuffing box. Reduction gears are made of chrome nickel steel and are hardened, ground and lapped. Gear shafts are ball bearing mounted and the whole mechanism runs in oil.

Washer with Automatic Timing Control

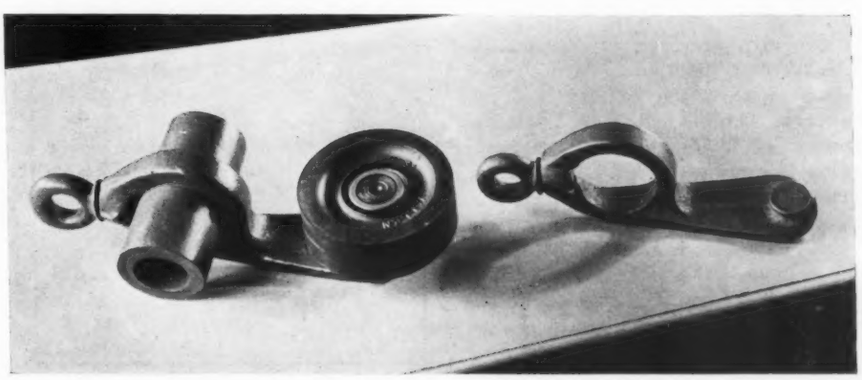


Automatically controlled, this high-speed washer, made by the Easy Washing Machine Corporation, Thomas J. Litle, Jr., Chief Engineer, has an electric timing device which may be set to predetermine the washing and drying period for different types of clothing, thus assuring a complete washing cycle in a minimum of time. A switch cuts out the electric timing device for non-automatic operation.

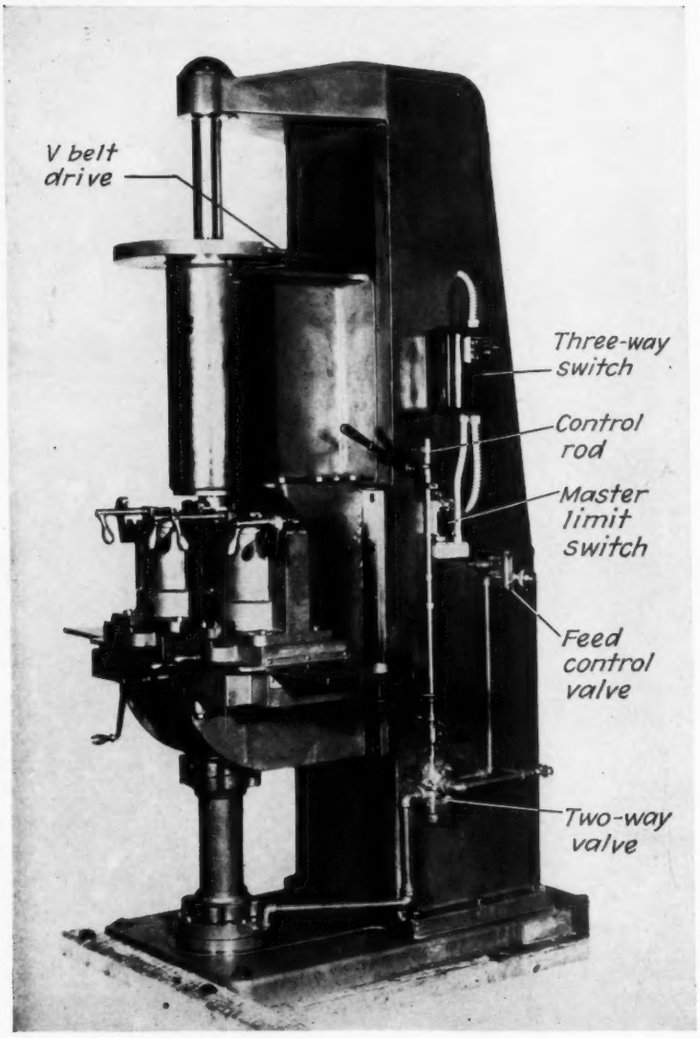
Two units, one a high-speed washer and the other a centrifugal dryer, operating simultaneously, cut washing and drying cycles to one-half of the usual required time. Precision ground surfaces and machined gears operating in oil insure quietness and long life of operating mechanism. Case with all bosses and flanges is machined to an accuracy of 0.0002 in. Motor mounting is an integral part of the gear case.

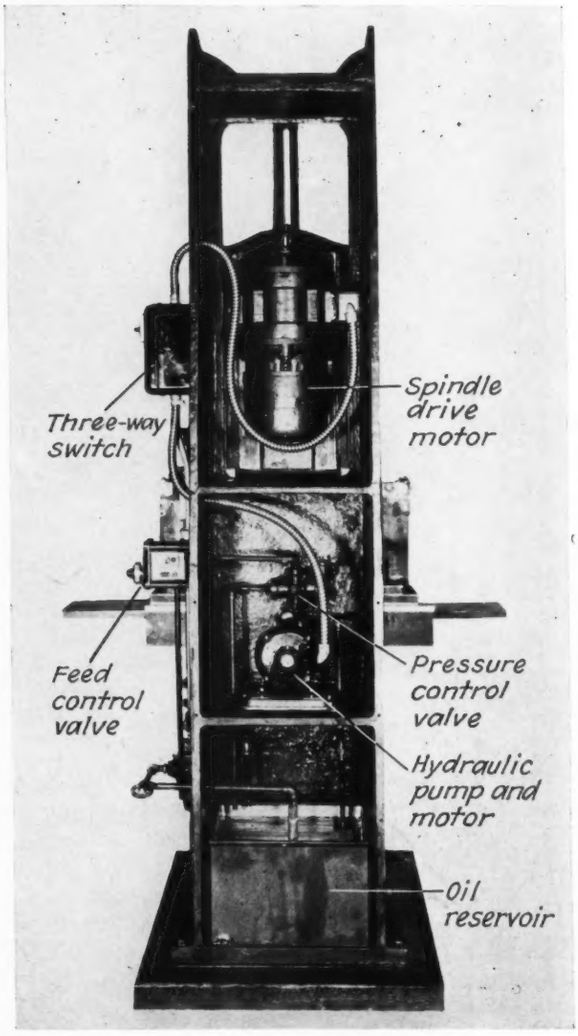


Coined boss on malleable iron casting permits accurate attachment of a ball-bearing wheel shaft. The thickness of the boss is held to size within limits of minus nothing to plus 0.003 in. Shaft projects through drilled hole in the boss and is then spun over. If the boss is not of the correct thickness, either too much of the shaft projects to prevent a tight spinning job, or not enough to hold shaft securely. The boss could be straddle milled to required thickness, but this is more expensive than coining. Casting produced by Vallen, Inc.



Modern Designs—Standard Parts Minimize Machining



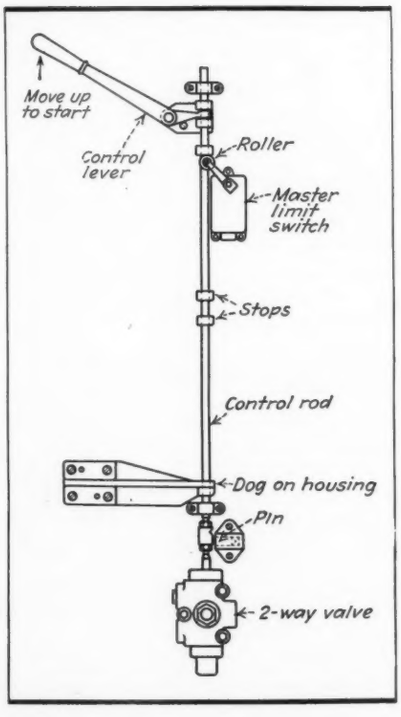


Diamond boring machine, designed by Neff, Kohlbusch and Bissell, uses standard parts in its control and driving system, thereby reducing to a minimum the accurate machining which is required to make it a precision device.

Precision manufacturing methods are required only for the spindle and table support assembly. Operation is by means of an interlocked electric and hydraulic circuit. Stops on control rod, contacted by dog on housing, determine stroke.

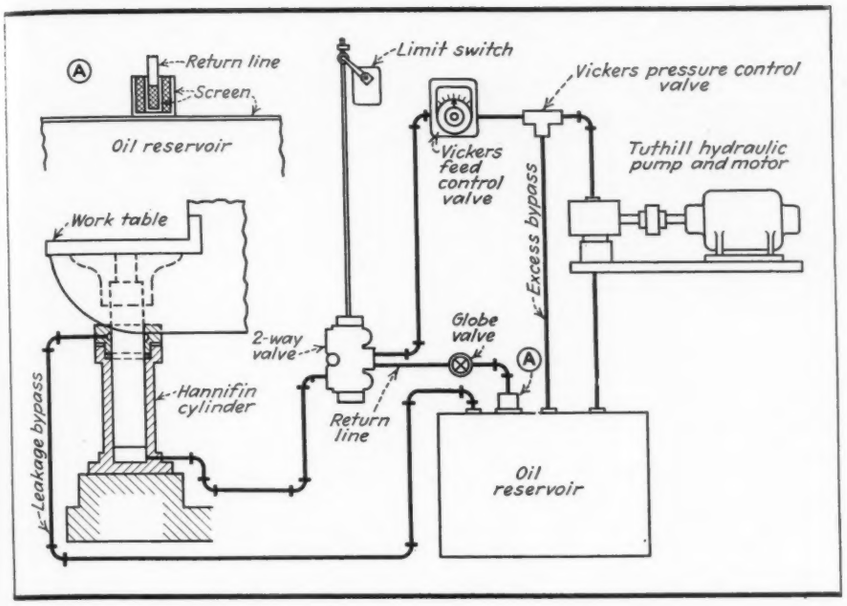
Two driving units are concealed inside the post, the upper a ¾ hp. motor which operates the spindle, and the lower a Tuthill ¼ hp. combination motor and hydraulic pump. Spindle motor is equipped with a Stearns Magnetic brake which stops the boring bar at end of stroke.

The oil reservoir is at the bottom of the column. The piston in the Hannafin cylinder which raises and lowers the C-shaped housing is cushioned to prevent shock on the down stroke.



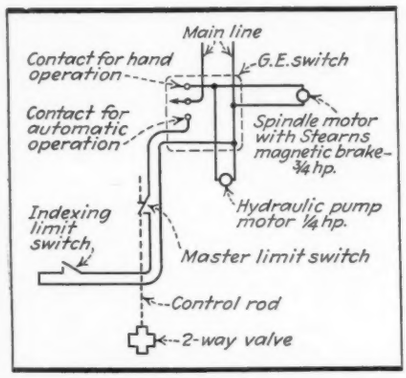
Control rod located on the side of the machine, operates the master limit switch and the two-way valve simultaneously. Rod is held down by a small pin forced into an indent by a spring. Dog, attached to the C-shaped housing, contacts stop on the control rod at the end of the predetermined stroke, and raises the rod. This throws the two-way valve and allows the spring action in the master limit switch to cut off the power to the two motors.

Automatic operation of the machine requires closing of the indexing limit switch first. Since this switch is in series with the master limit switch, it prevents closing of the circuit and jamming of the machine unless the work is directly under the spindle in working position. Index switch is placed below the index handle and remains open until the handle has been pushed all the way down, indicating that the index pin is then in the index bushing in the work pin.

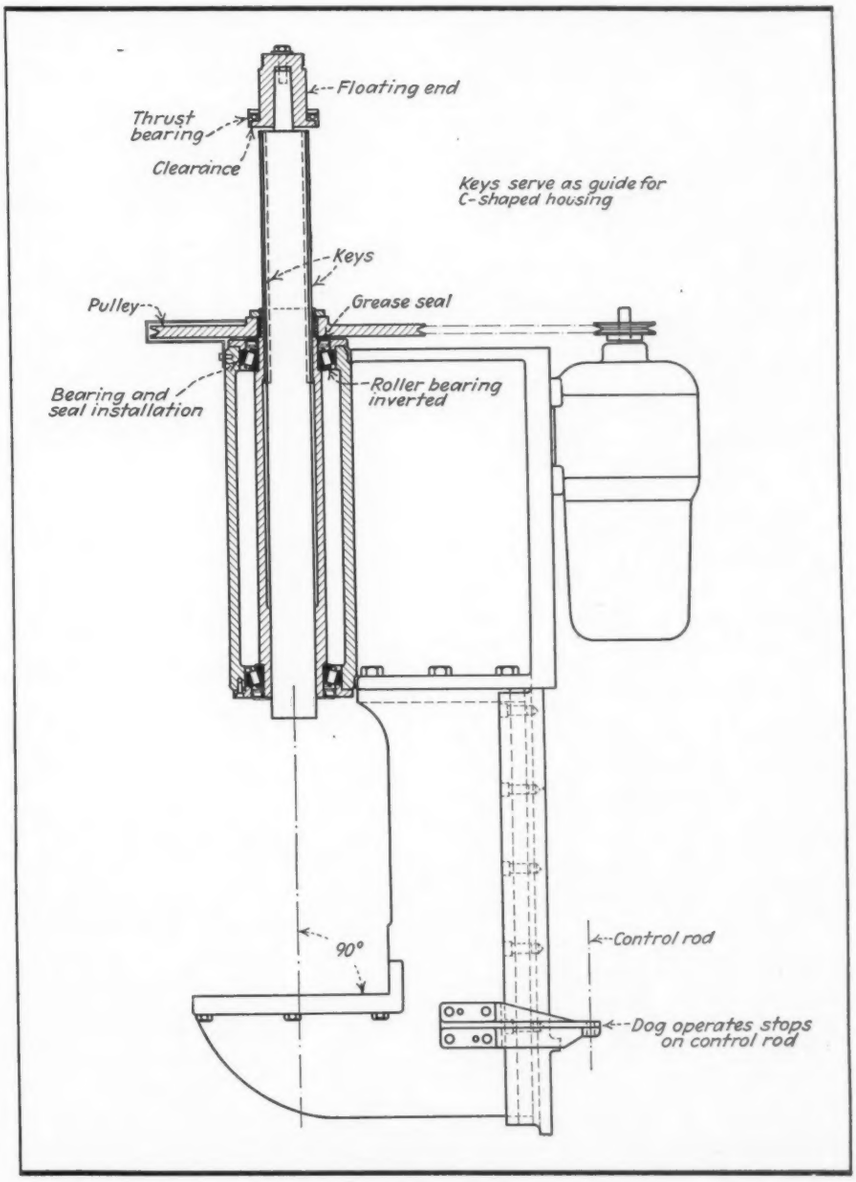


Machine accuracy depends on the two roller bearings which hold the spindle in the proper location with reference to work table, as shown below, the bearings having their centerline perpendicular to the table. The vertical ways on the column have no effect on the accuracy of the machine, as they and the pedestal support the weight of the housing only. Spindle drive is mounted on the back of this housing as part of the assembly. Boring bar remains stationary while the entire housing, boring bar driving mechanism and work table move vertically. Thrust on the boring bar is taken by fully floating thrust bearing so that any misalignment will not bend the boring bar. Upside-down installation of the roller bearings supporting the spindle and boring bar permits tightening up on the spindle by merely tightening the bearing cap bolt. Spindle is easily removed.

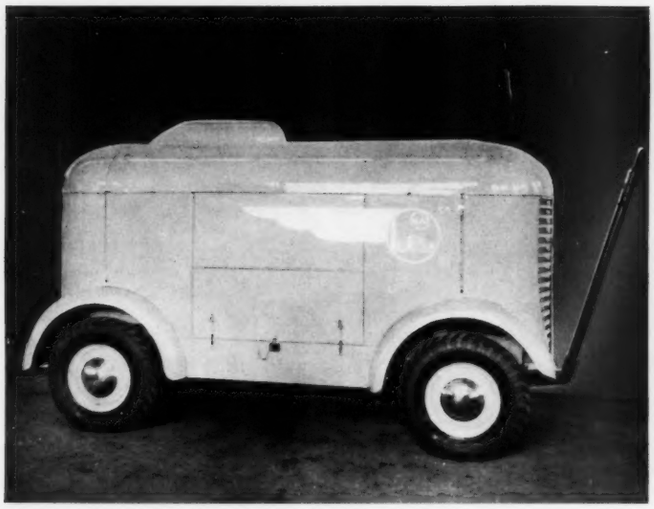
Two-way valve, when opened by by the lower end of the control rod, allows oil to flow into the pedestal cylinder. Rate of speed of the table is adjusted by a Vicker's Feed Control valve. Globe valve in the return line regulates the velocity and the return of the work table. Triple screen on the return line is intended to remove all air bubbles from the oil.

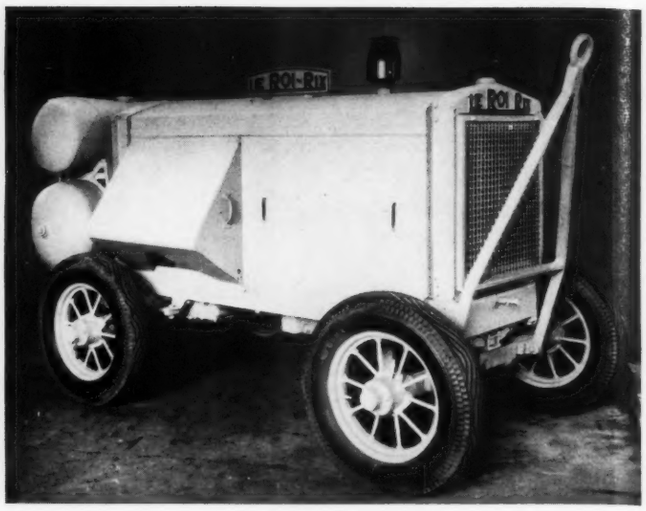


Three standard switches, controlling two motors, comprise the electric system. Three-way General Electric switch is used to change over from the circuit which contains the limit switches to the one which connects the main line directly to the motors. This latter circuit is used to stop the table and hold it in any desired position. When the circuit is operating, the control rod does not function; therefore, the two way valve remains closed and the hydraulic pump pumps oil through the bypass back into the reservoir, while the oil which is already in the cylinder is trapped and holds the piston and work table in place.

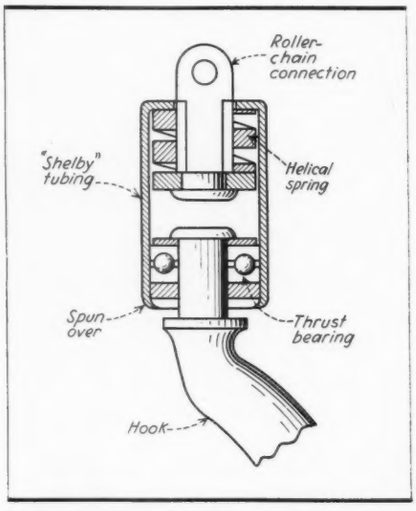


Modern Designs

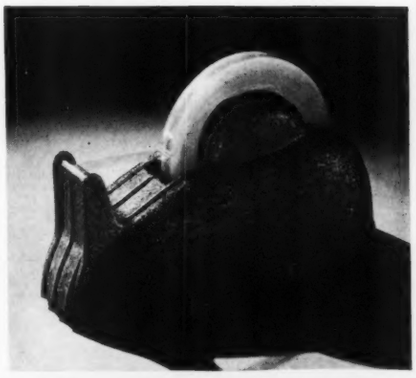


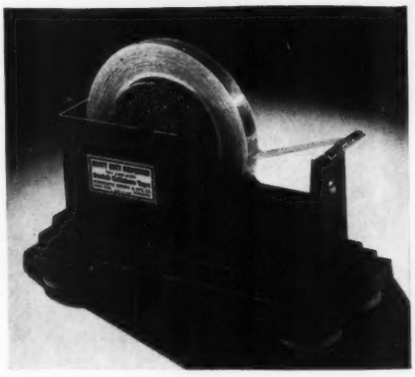


Welded steel construction was used for the redesigned housing of this LeRoi Airmaster air compressor. Both top and sides may be opened for complete accessibility. This streamlined compressor is painted yellow with silver and chrome trim. Styled by Wilbur Henry Adams for the LeRoi Co. of Milwaukee, Wis.

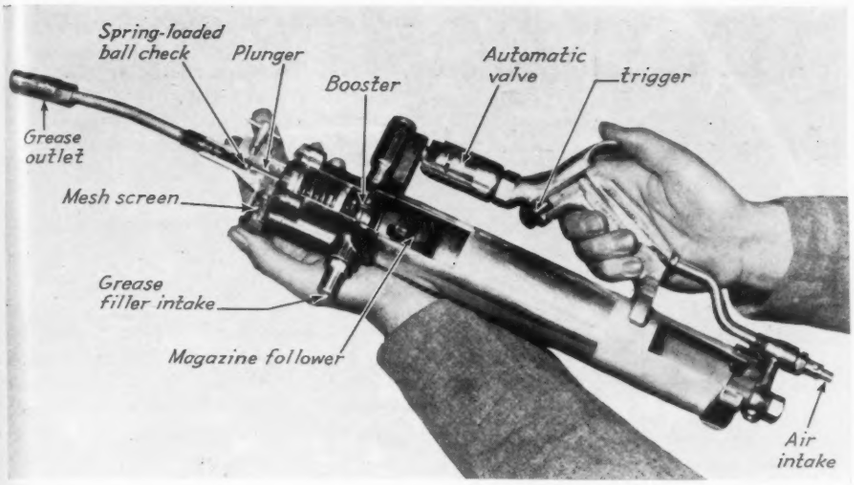


Cushioned load hook absorbs impact in new electric hoist developed by Manning, Maxwell & Moore, the load being transferred from hook to lifting chain through a compression spring. Roller chain, lighter for a given strength because of absence of bending moments as in open link chain, has higher efficiency and permits smaller diameter hoisting sprocket operating at greater r.p.m. for same lifting speed. This decreases the ratio of motor to sprocket shaft speed so that only two pairs of spur gears are necessary to secure the desired speed reduction. Gears, sprockets and shafts are of heat-treated alloy steel. Hardened steel shafts made the use of needle bearings possible. Thus, with a minimum number of parts, machine size and weight are a minimum. Claimed to be lighter than a hand-operated, spur-geared chain hoist of equal capacity.



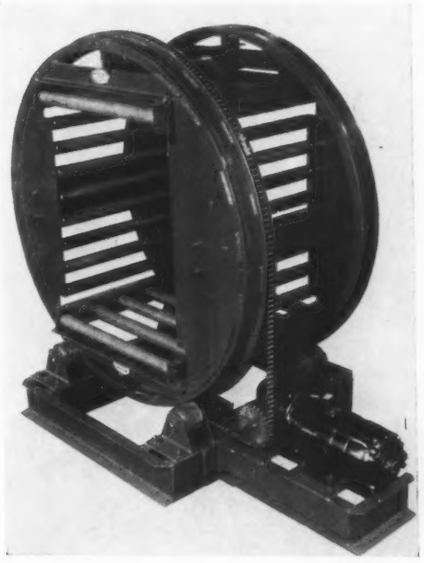


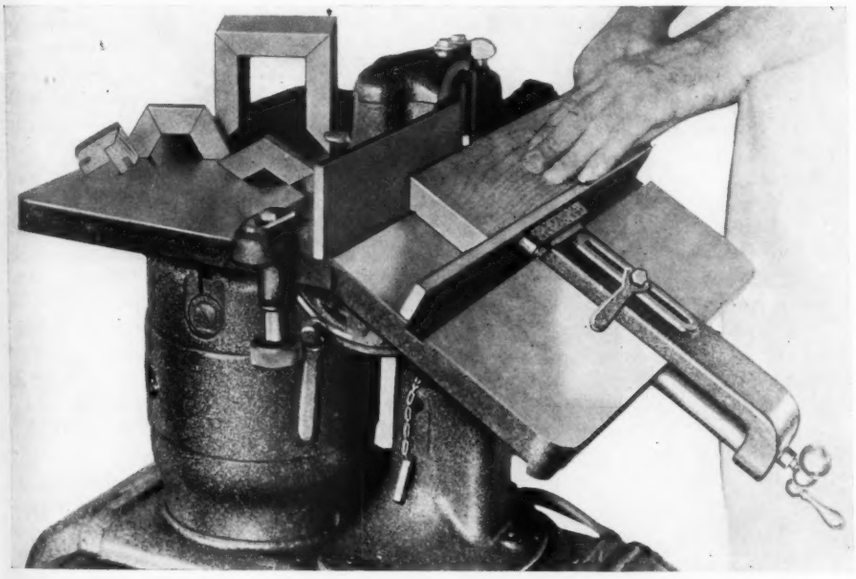
Better appearance, at no increase in production cost, was obtained by restyling this Scotch Tape dispenser. The old dispenser was a combined stamping and casting; the new one is entirely a die-casting. Finish on both is crackle-baked enamel. Inclosing the tape roll would have increased the cost without improving usefulness or attractiveness; whereas exposing it advertises the make and style used. Redesigned by Barnes & Reinecke for the Minnesota Mining and Manufacturing Company.



Light weight and sturdy construction were obtained in this Service Grease Gun by use of a drawn aluminum barrel and compact design using a minimum number of parts. Automatic valve produces 400 to 600 shots a minute. The high-pressure plunger is returned by a spring—the automatic valve piston always returns. This effects a saving in air over the pneumatic type, which is air-actuated both ways. Control valve has three parts, a steel piston, a cup leather and a nut on the end of the piston. Claimed to have 8 to 17 less parts than the ordinary pneumatic gun.

Power operated Roll-over designed by Mathews Conveyer Co., turns miscellaneous cartons 180 deg., automatically stops, then reverses to turn the next carton 180 deg. A limit switch, automatically engaged as the carton enters the roll-over, starts it; after 180 deg. rotation a second limit switch is contacted, stopping the unit. A built-in magnetic brake holds the motor in position at exactly the 180 deg. point. A switch is used to reverse the rotation for each succeeding carton.





Tilting table which permits cutting bevels and intricate molding with standard shaper knives is a feature of the new Shaper of the Yates-American Machine Company. Table, of heat-treated nickel alloy steel, is raised or lowered on an accurately ground column. Completely inclosed flat belt drive gives speeds of 8,000 to 10,000 r.p.m. Extra heavy base furnishes a rigid foundation for high speed operation.

RANDOM JOTTINGS ABOUT NEW DEVELOPMENTS

A new cylinder head, designed for 1937-38 Ford 85 hp. engine, is cast from a special copper alloy and uses a new "spot and fin" cooling principle. This "Thermo-Flow Power Head" announced by the Federal Mogul Corp., Detroit, Mich., permits higher compression ratios, and is claimed to increase power and mileage by virtue of its high rate of heat dissipation.

Iso-Elastic springs, immune to temperature changes, and dials on both front and back are features of the new Chatillon Scale. Essential parts are made of rust and corrosion resisting materials, pinions being of stainless steel, bearings of bronze, and housing of brass.

Noiseless cooling fan developed by the Dallas Engineering Corporation, features a propeller with three overlapping stamped aluminum blades. The fan is mounted on a heavy pedestal, adjustable from 5 to 8 ft. in height, and is trimmed in chromium and black.

Fifteen ton crane, built by the Cleveland Crane & Engineering Company, has every major section fabricated into a rigid one-piece unit by welding. Crane is assembled by bolting the major sections together.

Saving 90 per cent in weight, Amsco alloy mushroom valves weighing 80 lb. replaced cast iron valves weighing approximately 800 lb. for use on ingot soaking pits. Cast iron valves had to be water cooled for efficient operation, but scaled from oxidation resulting in a poor seal and air leakage into the furnace. The alloy used contains 26-28 per cent chromium and 10 to 13 per cent nickel, and, when exposed to temperatures up to 2100 deg F., is claimed to resist corrosion, abrasion and oxidation while retaining stren[illegible]

ELECTRONIC CONTROL

Light Relays and Optical Systems

RALPH A. POWERS
Vice-President and General Manager, Electronic Control Corporation

A following article will give in detail typical applications of standard light relays for the automatic control of machinery

PHOTO-ELECTRIC cells of the emissive group when coupled with electronic means of amplification are competent light-actuated production and control tools. Probably the simplest application of an emissive photo-electric cell and amplifier (a tube of the radio receiver family) is the combination of a gas filled photo-electric cell and an inexpensive Type 30 radio tube. Fig. 2 gives a graphic picture of this simple combination. In this typical circuit batteries are used. One battery supplies the external e.m.f. for the photo-electric cell—another the filament voltage for the amplifier tube, the third is the plate or "B" battery, while the fourth is the "C" or bias battery. Careful investigation of this fundamental circuit will reveal that as light is applied to the photo-electric cell, electrons move from the cathode, or light sensitive area, to the anode. This electron movement results in a flowing of electrical current between anode and cathode. The resistance of the photo-electric cell decreases. The value of the grid leak remains at a constant or previously selected value of from 5 to 20 megohms. The passing of current by the photo-electric cell naturally causes the grid of the amplifying tube to become positive with respect to the filament. Electrons are allowed to flow to the plate of the tube—the tube passes current—and a meter indication of from 1 to 5 milliamperes can be noticed in the plate circuit. The result—a few microamperes current change in the emissive photo-electric cell has produced sufficient voltage change across the grid leak to cause grid control of the amplifier tube.

Gaseous Amplifier Tube

In Fig. 3 the vacuum amplifier has been replaced with a small gaseous tube. Direct current is used on the plate of the amplifier and as soon as the photo-electric cell has caused the grid to swing sufficiently positive the tube is fired and maximum plate current flows regardless of increase or decrease of photo-electric cell illumination. A switch in the anode or plate circuit of the gaseous tube has been provided to extinguish or return the gas tube to unfired or normal position. Fig. 4 illustrates a gas amplifier tube used with alternating current applied to the plate. Decrease of illumination on photo-electric cell below the point of firing, unfires or extinguishes the amplifier tube, thus allowing on-and-off relay operation.

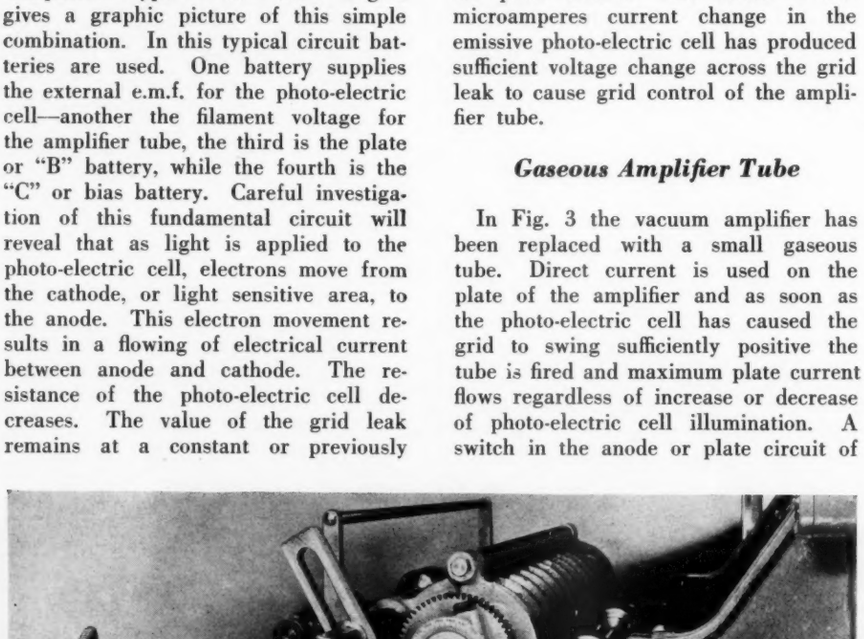


Fig. 1—The phototube has definitely entered industry. Here is an application by the Package Machinery Company, which uses them on most of the packaging machines they manufacture

Selecting The Three Elements

Because plate current in the amplifier circuit can be made to increase when light is applied to the photo-electric cell controlling the grid of this tube, it is logical to substitute for the meter a suitable relay in the plate circuit. The contacts of the relay or magnetic switch may be used to control motors, bells, lights, or solenoids such as used for automatic electric rejection.

The combination of a photo-electric cell, amplifier tube, relay or magnetic switch, and power supply is commonly referred to as a light relay or, by the newspaper writers, as an "electric eye."

To the designing engineer the selection of the correct combination of the three elements is very essential. If a radio amplifier tube, such as a Type 30, is used, the current in the plate circuit will range between 0.0005 amp. with no light on the photo-electric cell to 0.005 amp. with light on the photo-electric cell. A relay to operate on this 4.5 milliamperes current change must be sensitive and in practice is usually of the telephone type, having a d. c. coil resistance of about 3,000 ohms. In telephone or industrial practice this is one of the most reliable, long lived types of relays. It can not, however, be subject to heavy shocks. Contact pressure at a few milliamperes is in the order of a few ounces and a severe mechanical shock to supporting members will make the mass of the magnetic armature drop away from the pole piece of the coil, thus opening the closed contacts. Fig. 5 shows a complete light relay of an early model, using a telephone type magnetic switch with amplifier and photo-electric cell. If this type is to be used and severe mechanical shocks or vibration are to be experienced, the entire light relay or the telephone magnetic switch should be

cushion-mounted in order to avoid false operation.

A light relay of the type shown in Fig. 5 using a Type 112-A or Type 30 radio amplifier tube with telephone relay, normally requires for accurate magnetic switch operation a minimum of 1 foot-candle illumination of photo-electric cell and at least 50 per cent decrease and increase. The relay contacts have a maximum rating of 75 watts at 110 volts a. c. non-inductive load.

Numbered among a few of the common applications of the simple light relay are those uses where light is either "on" or "off" the actuating photo-electric cell and its associated light relay. Examples include:

1. Controlling conveyors by interception of the beam of light.
2. Automatic drinking fountains — where the interception of the beam of light actuates a solenoid water valve.
3. Opening doors upon interception of the light beam by the passing or entering object.
4. Controlling motors, such as conveyor motors, upon the interception of the light beam by passing objects.

The few listed applications of photo-electric cell and its amplifier to form a light relay gives a brief idea of the uses of frictionless control resulting from light beam interception.

In Fig. 6 is illustrated a more recent model of a single stage amplifier light relay. A comparatively "husky" magnetic switch or relay is used. The amplifier is a small gaseous triode tube commonly referred to as radio Type 885 and operates a relay or magnetic switch in its plate circuit, with contacts sufficiently large to easily handle the starting current of a 1/3 hp., 115 volt a. c. motor. The amount of change and minimum illumination of photo-electric cell are about the same as for the early light relay with telephone type magnetic switch. A light source, consisting of a 50 candlepower, 6 to 8 volt automobile headlamp bulb operating at 4.85 volts with a lens 3 in. diameter and 6 in. focal length will operate this light relay up to 60 ft. from point of light beam projection.

Optical Systems

Upon consideration of light sources, even for the most elementary light relay application, the engineer approaches the simple principals of elementary optics. In more advanced photo-electric cell equipment, to be discussed later, eighty-five to ninety per cent of the problem deals with the necessary optics to accomplish the job. With the use of lenses or mirrors in order to achieve the optical results, losses in light are tremendous. Hence much more sensitive photo-electric cell amplifiers are required, especially

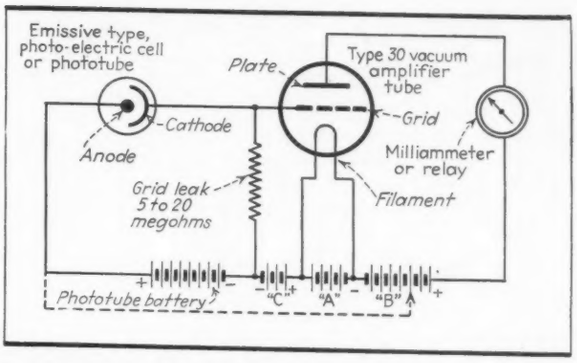


Fig. 2—Simplest form of emissive photo-electric cell coupled to a standard Type 30 tube. Dotted line shows how battery supplying phototube voltage can be eliminated by connecting anode to the plus terminal of the 90 volt "B" battery

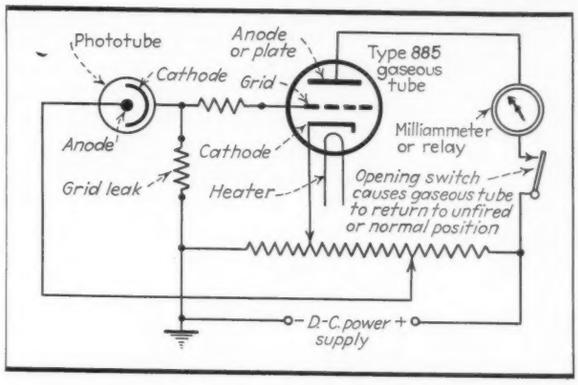


Fig. 3—Gaseous triode using d.c. With light on the cathode of the phototube, the plate current through the gaseous tube ranges from 0 to 75 milliamperes. Current being d.c. a switch in the amplifier anode circuit must be opened to break the current flow and restore the gaseous tube to normal

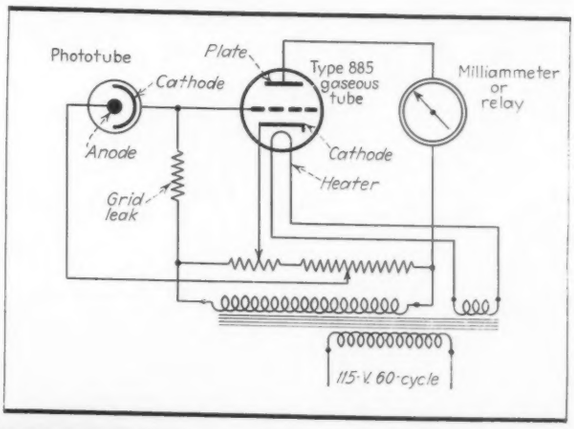


Fig. 4—Same gaseous triode arrangement as in Fig. 3, but with a.c. applied to the plate. This causes the gaseous tube to unfire and return to normal as soon as illumination on the phototube falls below the "firing point"

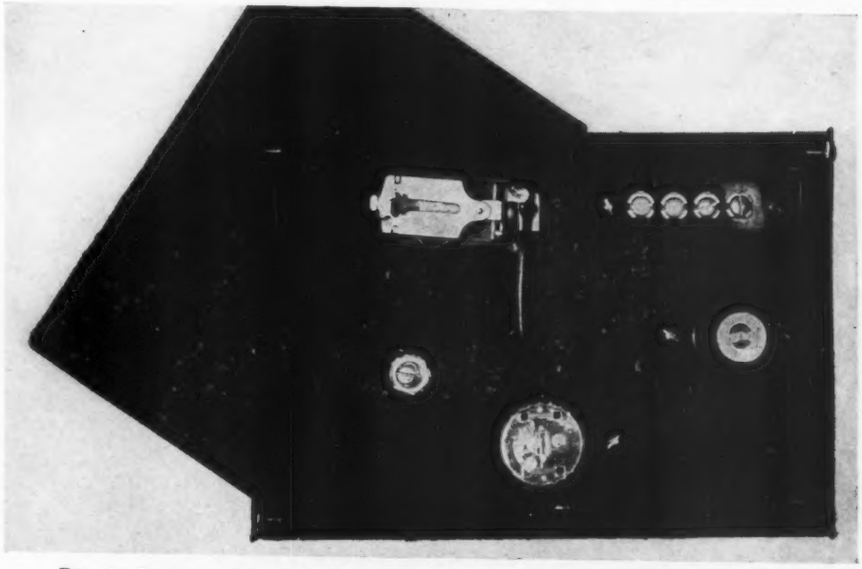


Fig. 5—Early model of an inexpensive light relay with a Type 30 tube to amplify the feeble current changes in the phototube so as to operate the relay in the plate circuit

for grading, sorting and inspecting.

In Fig. 7 is illustrated the combination of a simple lens in the air, a source of light, and at a distance the image of the filament projected upon the cathode of the photo-electric cell. This is the simplest optical group.

In simple forms of photo-electric cell applications for grading and sorting there is the problem of enlarging or magnifying the image of the object. Generally the light source brightly illuminates the control surface of the object. An objective optical system focuses on this brightly illuminated surface, enlarges it and projects it to the photo-electric cell or group of cells. In a simple example, a 1/10 in. change in object dimension must cast a shadow on three photo-electric cells. Because of space requirements these photo-electric cells are mounted on 2 in. centers. For every increase or decrease in object size of 1/10 in. the image projected by the optical system must move two inches. Accordingly, the optical magnification is of the order of 20 to 1. Fig. 8 is a sketch of a simple illustration.

Light Intensity Required

If 20 magnifications are necessary for photo-electric cell sorting, tremendous light losses will be incurred. Light intensity decreases in proportion to the square of the magnification in addition to which there are the losses through optics, transmission in air and the spectral losses due to lenses. Therefore, if a minimum of 1 foot-candle on the photo-electric cell is required, at least 200 or 400 foot-candles would be required on the object.

The curve in Fig. 9 gives estimated illumination values of standard incandescent lamps. Some rough calculations may be made from this as to the radiant energy necessary when a single stage photo-electric cell amplifier is to be used for grading and sorting to smaller limits.

Of course, grading, sorting, inspection and measuring with light beams and photoelectric cells is far more advanced than might appear from the elementary examples shown here. Following articles will set forth some of the more exacting applications.

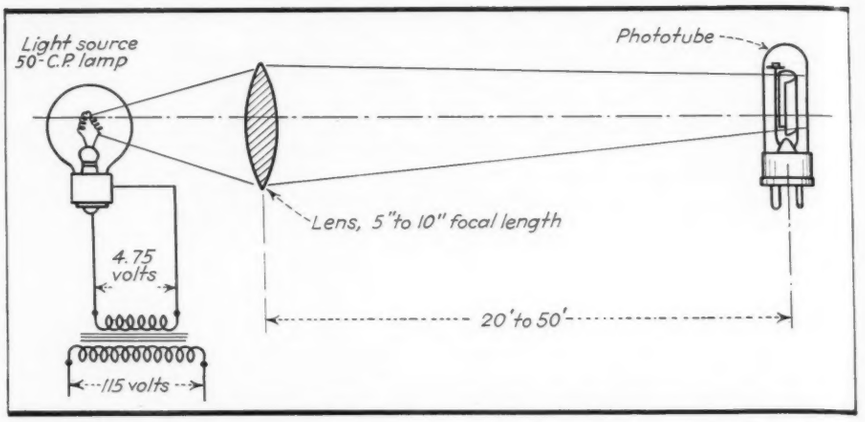


Fig. 7—The simplest optical arrangement for photo-electric control. The bi-convex lens picks up the image of the filament of the light source lamp and projects it on the cathode of the phototube

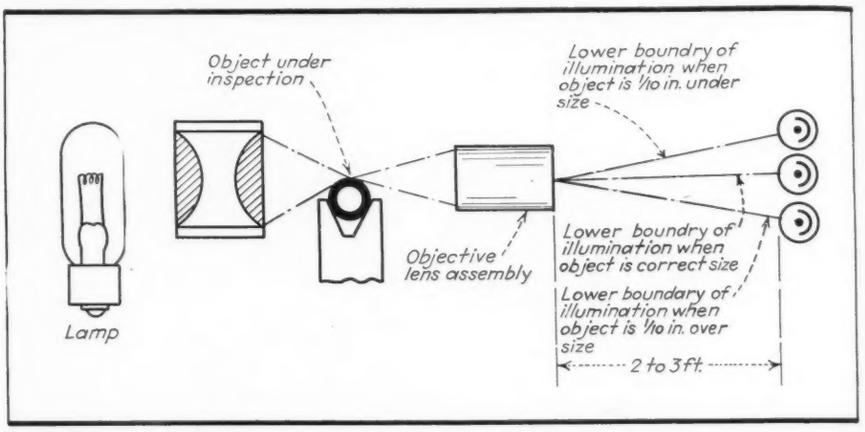
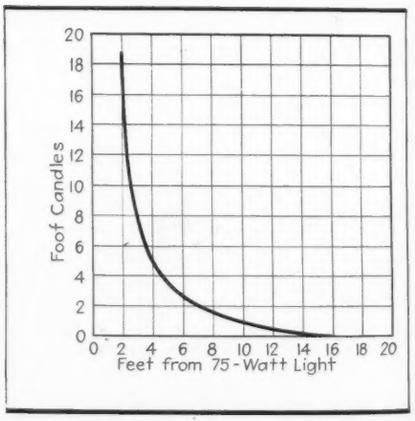


Fig. 8—Optical system magnifying an increase or decrease of 1/10 in. in size of object sufficiently to illuminate or shadow one of the three phototubes

Fig. 9—Intensity of illumination at various distances from a 75 watt lamp bulb. The average light relay requires a minimum of 1 foot candle to operate it



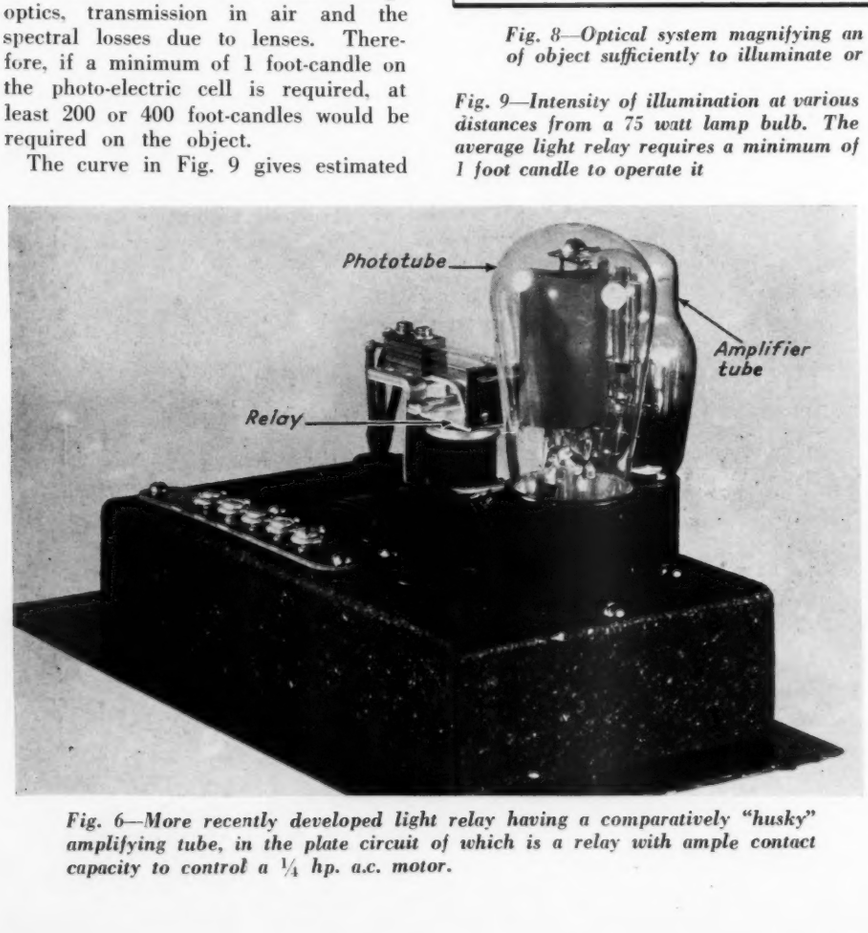


Fig. 6—More recently developed light relay having a comparatively "husky" amplifying tube, in the plate circuit of which is a relay with ample contact capacity to control a ¼ hp. a.c. motor.

MOTOR DRIVEN FANS

Their Early History and Development

A. F. WILCOXSON and T. C. LLOYD
Robbins and Myers, Inc.

The story of the evolution of the electric fan from an ancient lineage of hand driven fans is an example of how the design of devices is improved to meet advances in the use of power

IN COMMON with most devices, the electric fan has an evolutionary history involving a considerable change in design. And as usual, the forebears of the fan of today, when contrasted with our present standards are sometimes as ridiculous as our own devices will certainly seem in the future, a hundred years from now.

The use of the fan as an air stirring contrivance goes back before the days of written history. Some tombs of the Egyptian kings which date back to the eighteenth century B.C. reveal highly ornamental handles used with long leather fans. Around the eighth century A.D., the "punkah" fan was introduced into India by the Arabs. The punkah consisted of a mat of leaves or woven material suspended from the ceiling. In some complex installations this primitive fan was swung by cords running from the swinging element to a pedal located outside the room. The motive power was a boy called a "punkah wallah," and frequently he was required to work all night circulating air in his master's room. The master often found this means of air conditioning irregular and inconvenient; the boy's opinion is not known.

The earliest U.S. fan patent was granted in 1854. The design employed large blades, which were similar to those now used on ceiling fans. The blades were operated through a system of gears driven by an electric motor energized by batteries. Prior to this, however, similar fans were driven by spring motors, although apparently no patents were recorded for the idea.

Starting with the rise of the central station industry in 1888 the popularity of the electric fan increased and by the 1890's production of fans was on in earnest. During that decade the desk, bracket, ceiling and ventilating types of fans were all developed.

An interesting ventilating fan can be traced back to Benjamin Franklin. If it were possible for one of our generation to visit Franklin's kitchen great would be the surprise to find in the kitchen wall an apparently up-to-date bucket blade ventilating fan connected by pulley and belts to a spit set up in front of the fire-place where cooking was done by the family. This fan was really a "wind-mill" so arranged that the fire which cooked the joint for dinner, also created a draft which pulled in air from the outside to turn the fan and the meat.

Because India was the largest potential foreign market for the early electric fan, it was natural that an attempt should be made to build an electric punkah in which the "wallah" was replaced by a motor. France, Switzerland, and England all competed with the United States in this market, the latter doing a large business in ceiling fans similar to the present designs.

Swiss and French fans (or as they called them, "eventails avec moteur mechanique") are illustrated in this article. They were advertised as being desirable "to keep off troublesome insects and make the heat more tolerable."

The punkah depicted in Fig. 1 was exhibited in 1900 at the Paris Exhibition by Mr. Heinrich Spuhl, a Swiss manufacturer. The lady at the extreme left is not selling flowers, she is advertised in the catalog as a dust proof cover for the motor, size J. Several other frame sizes, some of which were less openly ventilated, were available for the fastidious customer.

Neat and not so gaudy, the punkah shown in Fig. 2 was designed for office installation, it was advertised as portable and "so simple to operate that it could be plugged into the electrical outlet by the first workman on the job."

A complete air conditioning system

Fig. 1—One of the exhibits at the 1900 Paris Exhibition. This punkah fan could be furnished with a compressed air, an hydraulic or an electrical motor for operation

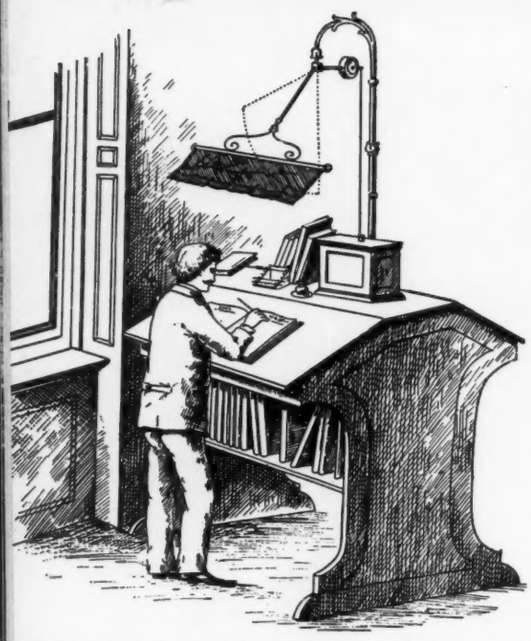


Fig. 2—A motor driven punkah for the office "so simple to operate that it could be plugged into the electrical outlet by the first workman on the job"

for the home, vintage of 1900, is delineated in Fig. 3, punkahs on each floor were operated by cords connected to an hydraulic motor in the basement. To install, one had only to dig a large cistern and to construct an attic tank "of equal capacity." Water was pumped by hand from the cistern to attic tank whence it flowed down through the hydraulic motor to generate motive power. A ratio of 1/10 was claimed for this device meaning that the operator pumped water into the tank for one hour so that the punkah could operate for 10 hours. The other containers in the basement probably had nothing to do with the hydraulic system.

Some quotations from the advertising leaflets of M. Spuhl as circulated in 1900 are enlightening. " . . . After many attempts I have succeeded in solving the problem (of fan design) satisfactorily by electrical and also by hydraulic means; or compressed air may also be used instead of water, or again the fan may be set in motion by a specially constructed mechanism by transmission, which however would only be exceptional.

"In America, for some years, electric punkah-motors with rotating wings have been made, which move the air constantly in the same direction, and after the manner of a bellows. In spite of the almost unpleasant effect, for lack of something better the manufacture there has grown into an important industry.

"My punkah-motors move the fans swinging slowly to and fro, and cause a pleasant current of air, like the fan which ladies carry. These swinging fans give a very extended movement of air compared to those with rotating wings, so that in a large room half of these fans suffice, and the air is moved almost uniformly at every height down to the floor, while with fans with rotating wings . . . people who are short or are sitting miss the benefit, and it cannot be used in bedrooms, and is therefore of no use for invalids.

"Anyone who remains long close under a punkah with rotating wings will try and change his place out of consideration for his health."

Having thus disposed of the rotating ceiling fan in a breath, so to speak, the type of oscillating punkah advocated by the above advertising copy was in turn attacked by the English manufacturers. The English are generally considered as being victims of habit and tradition. They were not accustomed to seeing the punkah oscillate back and forth with a uniform movement. The native boy had a special technique, giving a peculiar "flick" to the motion. Hence, so that the English sahib would not be disturbed by anything too novel, English-made punkahs were designed to flick irregularly. (Before we laugh at English conservatism, let us recall our own first automobiles, built to look like carriages.)

The English arrangement, shown in Fig. 4, consisted of a rigidly suspended motor having a conical pulley keyed to the shaft and a swinging frame to which a short curtain was loosely hung. Attached to the frame was a spring controlled quadrant pivoted on a bearing pin. The quadrant made contact with one side or the other of the cone pulley, the punkah was thus carried away from

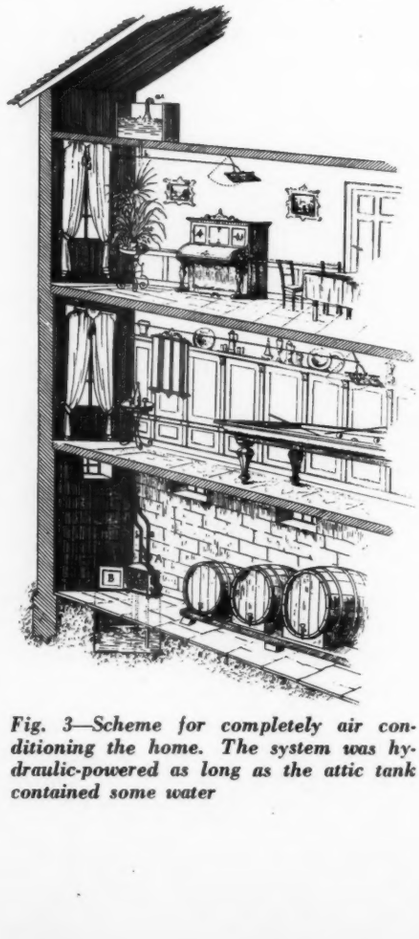


Fig. 3—Scheme for completely air conditioning the home. The system was hydraulic-powered as long as the attic tank contained some water

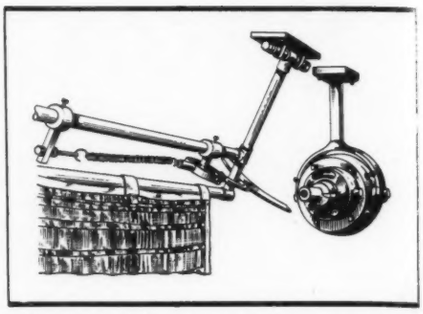


Fig. 4—An English development with a special motion which imitated the "flick" of the hand-pulled punkah. As shown, the quadrant is about to engage with the pulley on the under side

the vertical position clear of the pulley to a point from which the punkah swung back by gravity. On the return stroke the quadrant struck the opposite side of the pulley and swung the punkah in the opposite direction with a "flick."

Hastening the Millennium

But to let their advertising leaflets speak for themselves: "One of the dominant notes of the present age (*circa* 1900) is "Hustle." It is expressed in the many labor-saving devices which surround the merchant in his office, in the shape of electric bells, the telephone, and the typewriter . . . Everything that saves labor is welcomed as hastening the advent of the millennium. . . . The high pressure blower ousts the hand-worked bellows of the much be-sung "Village Blacksmith;" and last, but not least, the Electric Punkah has come to replace the loin-clothed, lean, and often lethargic native punkah wallah . . .

"Inventors had no difficulty in producing a device that looked like the hand-worked punkah—this was a simple matter—and many such have been placed on the market from time to time . . .

"One of the greatest difficulties inventors had to contend with, was the reproduction by their mechanical devices of the "flick" peculiar to the hand-pulled punkah, and which indeed is necessary if the apparatus is to be practical.

"Another stumbling block has been the inability of inventors to construct a machine which would be noiseless . . . All these difficulties have at last been solved by the Patent Electric Punkah . . . (which) embraces all of the salient qualities of the native-pulled machine, and while avoiding all the faults, embodies all the virtues . . . "

Although the advertising statement implies that the punkah was hand operated originally, foot power must have been common also. By 1915 the electric fan development of one type or another introduced a serious problem in India. Quoting from a newspaper account:

"Captain Fitzgerald Smith-Duncan, on

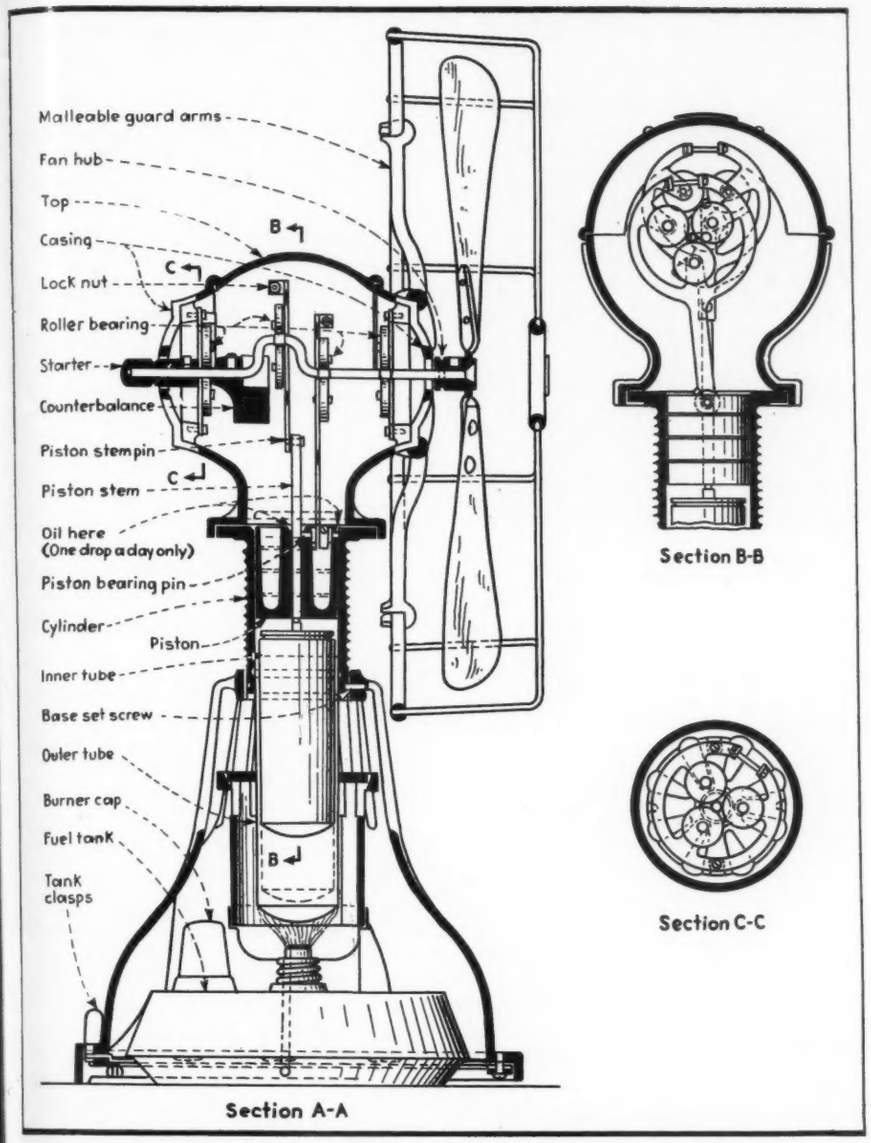


Fig. 5—Cross-section of a fan driven by a heat engine with an alcohol burner. If gas was available a gas burner could be substituted for the alcohol burner. Note the roller bearings

his way from India to join his regiment in France . . . told of a remarkable situation confronting the British Government . . .

"There is no danger of cholera, there is no fear of a mutiny. The big problem there is the disposition of the punkah wallah . . . The universal introduction of . . . electric fans in India has thrown thousands of the punkah wallahs out of jobs . . .

"The punkah wallah comes down through long generations. You can tell one by the peculiar motion of his leg . . . they tried them out in the army, but they couldn't march, because their step is like that of the famous sidehill setter. Now they don't know what to do with the thousands who are out of work." Surprisingly enough the fan created technological unemployment.

The evolution from punkah to ceiling fan has not ended there, for at the present time the ceiling fan is being largely replaced by complete air conditioning systems or the more effective air circulators.

Aside from the battle of the punkahs, fan design in the United States underwent gradual development throughout the first years of the twentieth century. The more common desk fan has almost as interesting a history as has the ceiling fan. Desk fans were first constructed using blades without guards, and with no attempt to modify design to achieve eye-appeal. The d.c. or split-phase a.c. motors then used for motive power were extremely heavy and clumsy, according to our present standards.

By 1915 electric power was still not so prevalent and other types of motive powers were commonly used to operate fans. A good example of a fan driven by a miniature heat engine is shown in Fig. 5. This engine required an alcohol or natural gas burner. Nothing is said about air delivery, but a study of the advertising matter of the more reputable makes of electrically driven ceiling fans reveals that air delivery, power required and speed, were specified even prior to 1910, and also guaranteed.

Advancement in electrical fan design during the past twenty years has followed three trends of importance: eye appeal with increasing stress on attractiveness of the fan, reducing noise through better blade and motor design and increasing overall efficiency. Thanks to the progressiveness of fan manufacturers, applications have broadened widely since the day when the two chief sales points were "making the heat more tolerable" and "chasing flies from the dining room table."

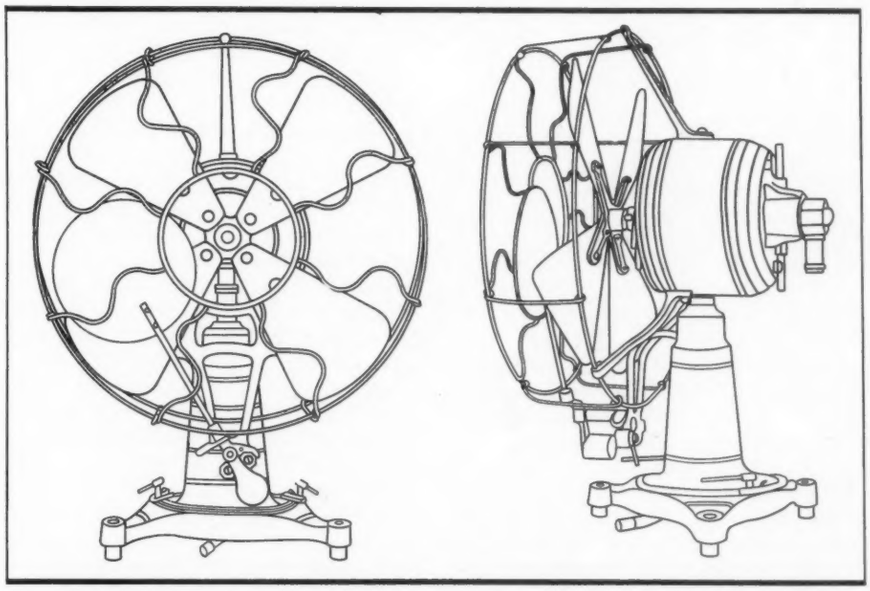


Fig. 6—One of the early schemes for obtaining a fan oscillating movement. The periodic movement of the shield from side to side resulted in a reaction on the blades that caused the oscillation

Wire, with flawless multiple coatings of pure zinc, in leaving the electro-galvanizing unit at Republic Steel Corporation's new wire mill, passes through a steaming water rinse and dries on its way to the three take-up frames which have a total of 40 individual reels

METALLIC COATINGS

For Protection and Appearance—II

J. DELMONTE

Properties of electroplated coatings of nickel, chromium, silver, gold and rhodium and precautions to be observed in their application. Part I appeared in the March number

MOST of the metallic coatings discussed in the previous article are primarily for the purpose of protection against corrosion. Where appearance is the major consideration, nickel, chromium, silver, gold or other rare metals are generally used. One is not to infer, however, that other platings do not have a pleasing appearance. For example, the bright silvery-white appearance of cadmium is frequently the reason for its selection. And conversely the selection of a plating metal for purposes of appearance must always consider its corrosion resistance properties.

NICKEL—Nickel is one of the most attractive coatings from an appearance standpoint. Its resistance to wear and general corrosion has strengthened its appeal. The nature of the nickel is greatly influenced by the electro-plating conditions. Careful control over the bath composition, operating temperature, and current density is important. Hard, bright, and dense nickel deposits are obtained at current densities of 20–25 amp. per sq. ft.

Agar-agar, dextrine, Turkish red, or complex aromatic sulphonic acids, when added to the plating bath, brighten the nickel deposits. Bright nickel deposits may also be achieved with cobalt-nickel anodes. When zinc die castings are being nickel plated, the addition of cadmium sulphate to the bath will augment the attractiveness of the nickel coating. It is important in nickel plating to agitate constantly the solution about the work to remove the suspended particles which cause rough and pitted finishes. Zinc die-castings are utilizing bright nickel deposits to a large extent. Commercially the particular system employed is known as the Hanshaw method. A brightening agent, organic carrier, and a reagent to help maintain uniformity of coating are aded separately in proper proportions. Zinc die castings intended for severe service will have as much as 0.0008 in. total thickness. Sometimes a copper flash is employed, though some authorities question its advantages.

The plating on aluminum and aluminum alloys by nickel or other metallic coatings, requires special methods. Aluminum rapidly forms a hard, impervious oxide layer, upon which other metals will not adhere. One method of electroplating aluminum purposely oxidizes the aluminum surface and then removes the oxide layer by an acid etch. The flow roughened surface will hold metallic coatings better than before. A good etching bath for aluminum contains sodium fluoride and sulphuric acid, followed by nitric acid.

Softer nickel coatings are required on products that are to be buffed. The buffing operations will close small pin holes on the surface of the coating. Barrel burnishing of small nickel-plated parts is a common practice to improve luster and appearance. If black nickel deposits are required, special salts may be added to the plating bath to give the desired results. As a basis for chromium deposits, the thickness of the nickel layer may be as low as 0.0002 in. or 0.0003 in., but thicker deposits are necessary for good resistance to general atmospheric corrosion. About 0.001 in. to 0.002 in. nickel plating will give good service in severe outdoor exposure.

Nickel plating possesses advantages in certain applications, not held by other metallic platings. For handling phenolic resins in the manufacture of plastics, a heavy nickel coating must be used in contact with the ingredients, as it will not react with the mixture. Tinned cop-

per coatings in such applications, imparted a cloudy appearance to an otherwise clear mixture. Nickel and monel metal have been used frequently in chemical process equipment, in their pure solid state. A saving in expense is realized when nickel is mechanically rolled on steel sheets at elevated temperatures, and the resulting laminated sheets, adequately protected, are used in the construction of the apparatus.

Nickel plating also offers good protection to equipment handling petroleum products or gasoline. Water associated with these hydro-carbons has a highly corrosive action on metals, particularly ferrous parts. The mechanism of the protection by nickel differs from that of the softer metals, zinc, tin, and cadmium. A dense coating prevents access of the corroding influence to the surface being protected. A flash coating of copper under the nickel plating tends to improve the soundness and resistance to corrosive influences.

CHROMIUM—Chromium plating is one of the most popular of metallic finishes, leaving on the surface a lustrous, silvery, hard coating. For decorative purposes, it is indispensable to household metalware and appliances, some of which are shown in the accompanying illustration. Chromium will not visibly tarnish over prolonged interior use. When corrosion does attack the base metal, it commences at distinct spots on the chromium plating.

The excellent wear and abrasion resisting qualities of chromium are made use of on special steel gages and knife edges, where precision parts and instruments may be affected by the wear. Heavy coats of chromium, 0.003 in., are used directly on steel dies, tools, and jigs, where resistance to wear is of primary importance. The tools and dies are ground down to finished dimensions. Recent Vickers scratch tests for hadness of hard chromium deposits reveal, when converted into Brinell numbers, a hardness range of 400–800 Brinell. Chromium-plated sheets have lengthened the life and serviceability of the molds used in connection with plastic manufacture. A hard chromium deposit may be obtained only in certain chromium plating baths under specified conditions. In general, the following precautions must be obesrved to obtain hard deposits:

(a) Optimum bath temperature, about 50–55 deg. C.

(b) Minimum of SO_4, C^1, Br, and F ions in solution.

(c) High current density, 80–200 amp. per sq. ft.

(d) Chromic acid used as a base in the plating solution.

NICKEL - CHROMIUM — The greatest popularity that chromium plating enjoys is in those applications that utilize a nickel, or nickel-copper undercoating. The chromium plating is greatly dependent upon the thickness, adhesion, and freedom from porosity of the nickel coating. One of the most notable examples of a durable plating which is subject to all conditions of abuse and wear is the protective metallic coating given to automobile radiator grilles. Prior to plating operations, the illustrated radiator grille was polished upon a buffing wheel. The radiator grille plating was about 0.001 in. thick, of which 0.000025 in. was chromium, the remainder copper and nickel. The bimetallic and trimetallic coatings with an exterior of chromium are popular for some of the medium and larger zinc die-castings. The following are typical platings for zinc die-castings, for various applications:

For interior exposure such as for novelties, containers, and hardware use plating combination of Nickel 0.0003 in. (min.), Chromium 0.00001 in.

For outdoor exposure such as for automobile hardware (running board molding) use plating combination of Nickel 0.0005 in., Chromium 0.00001 in.

For severe outdoor exposure such as for building decoration, auto radiator grill use plating combination of Copper 0.0003 in., Nickel 0.0005, Chromium 0.00002 in.

The nickel-chromium combination for outdoor exposure is a good plating for general application. A current density of about 40 to 100 amp. per sq. ft. is maintained in the bath. For a less bright, "butler" silver finish, scratch brushing prior to plating operations will give the desired results. Dark or black chromium plating is obtained at extreme current densities of several hundred amp. per sq. ft. The addition of acetic acid augments the depth of the black chromium plating, as will an undercoat of black nickel.

Chromium plating does not compare favorably with other plating solutions in the throwing power of the solution. Small crevices and recesses do not receive as thorough a plating as large, smooth exposed surfaces. A rapid agitation of the solution, frequently replaced anodes, proper bath temperature, and a close chemical control, will allow worthwhile deposits of chromium. Chromium can only be still plated, and can not be barrel-plated.

ALUMINUM—Aluminum has been the subject of recent researches, purporting to deposit it electrolytically upon other metals, with an inexpensive practical method. While specific success has been encountered on a small scale, large scale applications remain to be proved. Spraying molten aluminum has always been possible, but only for large objects. Calorizing, analogous to sheradizing, permits aluminum vapor to coat parts at 1,500–1,800 deg. F., but the method is expensive. A recent patent (U.S.P. 2,082,662) describes a method of applying molten aluminum on wires, in a manner similar to hot-dipping. The wire is cleaned, passed through a boric acid bath, and into a reducing furnace. The metal will now form a tenacious film with aluminum, when it is passed through a molten aluminum bath. This method, previously discussed in *Product Engineering*, is being applied commercially.

Recent patents (U.S.P.—2,100,255; 2,100,256; 2,100,257; and 2,100,258) describe methods of applying aluminum by cementation processes. For example, in aluminum-plated zinc or magnesium, the base metal is applied to the inner face of the aluminum which is to serve as a sheath. The oxide film is broken down and an alloy is formed. The core metal may be then fused to the inside of the sheath. In this manner, a laminated billet is formed, which may be rolled into sheet form. Subsequent working of the laminated metal does not destroy bond.

Electroplating aluminum has been carried out in baths of halogen salts at elevated temperatures of 210 deg. to 120 deg. C. Freedom from iron is essential. Smooth deposits of aluminum are claimed by Japanese investigators, by superimposing 10 per cent a.c. on the direct current. A previously cleaned, highly polished surface is necessary. Aluminum die-castings are sometimes finished in frosted or satin finish, by scratch brushing, without further finishing. Aluminum possesses a tenacious, thin, oxide film that serves as an excellent protective coating for the remainder of the metal. Until this coating can be commercially applied to other metals, aluminum as a protective coating will not find very wide application.

A miscellaneous coating for aluminum (U.S.P. 2,095,256) has advantages in preventing the seizure of aluminum threads. The anodic coating of aluminum is treated with a volatile solvent lacquer, and a stearate of zinc, aluminum, or lead. The solvent is vaporized, and a thin, protective coating of the stearate remains.

SILVER, GOLD, AND RHODIUM—One of the largest applications of silver plating is on hollow-ware, where a combination of four or five different metals such as silver, copper, brass, tin, britannia metal, lead solder, etc. offers peculiar difficulties. These metals must be coated simultaneously, requiring a special plating bath and technique. The articles are first plated with copper during a short striking period while being rapidly agitated in the solution to shake loose the gas bubbles. Silver plating follows, at low current densities.

RESISTANCE WELDING

Principles and Design Data—III

L. H. FROST
Welding Engineer, Electric Controller & Mfg. Company

Properties of electrode materials, the design of welding tips and electrode holders, and timing methods used. Part II appeared in the March issue

MANY ALLOYS for use as electrodes are available, nearly all being copper alloys. The desirable qualities of such an alloy include maximum electrical conductivity, maximum thermal conductivity and high strength. Of the common metals, copper has the greatest electrical and thermal conductivity but may not possess the desired mechanical properties. By the addition of proper alloying elements and proper heat-treating and mechanical working, the strength of the copper electrode material can be increased without an appreciable loss of electrical or thermal conductivity.

The strength of the electrode material is important in that the life of the electrode depends upon its resistance to wear and deformation under heat and pressure. Although it is possible to obtain relatively high strength in copper by suitable cold working without decreasing the electrical and thermal conductivity to a marked degree, the electrodes will become heated and thereby return to their annealed condition when they are used in continuous production or long welding periods.

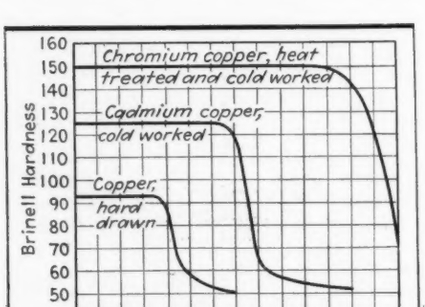


Fig. 19—Curves showing the effect of annealing on the hardness of copper-alloy used for welding electrodes

Principally among the alloying elements used in preparing copper alloys for electrodes are cadmium, chromium, tungsten and beryllium. All of these alloys have less conductivity than pure copper and all have greater strength. Table I gives the conductivities, strength and hardness of these alloys. While the exact composition of these alloys are more or less trade secrets, the percentage of the alloying element is small. The cadmium and beryllium groups contain approximately 3 to 5 per cent, the chromium group about 1 per cent and the tungsten group also small percentages. Fig. 19 shows the effect of annealing. Not only does the softening of the electrode material shorten its life but it is equally undesirable in that it increases the electrode contact area when the electrode is subjected to pressure when welding. In Fig. 20 is shown the effect of this for average current and pressure.

Another important group of alloys used for welding electrodes are the copper and silver base alloys using tungsten, molybdenum and their carbides as alloying elements. These alloys will not soften under red heat and hence resist to a marked degree enlargement of the tip diameter and wear of the contact surface.

The choice of proper electrode material is largely determined by balancing the first cost of the alloy as compared to copper against the cost of maintenance and operating efficiency. In the welding of steel pure copper electrodes are desirable, although not necessary from the viewpoint of conductivity. The electrical conductivity of steel being approximately 1/7 that of copper there will be approximately seven times as much heat developed between the sheets as developed at the outer surfaces between the electrodes and the sheets. Hence when welding steel an alloy having a conductivity 85 per cent of copper will provide welding heat of six instead of seven times the outer surface heat and this change will not be great enough to cause any noticeable effect when operating under normal conditions. With an alloy having only 25 per cent conductivity, only 1¾ times the outer-surface heat will be developed between the sheets and difficulty may be encountered in obtaining a satisfactory welding condition. In most cases the heat developed at the outer surfaces is undesirable in that it causes oxidation and discoloration as well as indentation at the weld.

The effect of heat produced at the sheet surface under the welding tip is not in direct proportion to the electrical conductivities. The greater thermal conductivity of the electrode conducts heat from the outer surfaces and thus the temperature at these contact points will be much less than the electrical resistances of the materials would indicate, depending upon the amount of heat conducted away while welding and between welds.

A process using this principle is commonly called "wood-pecker" welding because the current is interrupted while the electrodes maintain pressure on the work. This method has application in welding thick sheets or plates. By interrupting the current while the electrodes are still in contact with the work the heat developed at the outer surfaces is conducted away by the electrodes while the heat developed between the sheets is built up by the repeated applications of current. The thermal conductivity of steel is approximately 15 per cent that of copper hence the electrodes conduct heat from the surfaces seven times as fast as the heat from the inner surfaces is carried to them.

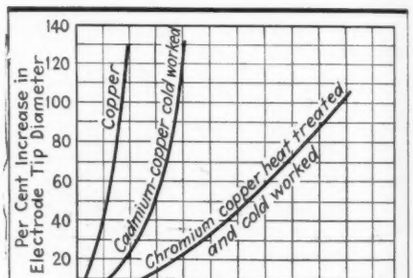


Fig. 20—Relative change in diameter of the electrode tip as a result of annealing caused by the welding current and the action of welding pressure

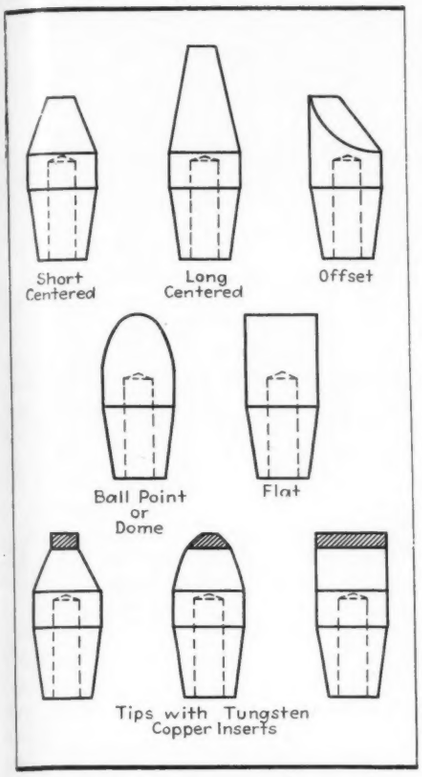


Fig. 21—Commonly used shapes of replaceable tips for welding electrodes

Life of electrodes depends upon their diameter, the material being welded, the strength of the electrode and the permissible enlargement of the contacting area. The alloy electrodes may be expected to give from three to eight times the life of copper electrodes. A reasonable allowance for increase in tip area is 100% which is equivalent to an increase in diameter of 42 per cent. When this increase is reached the electrodes should be reshaped.

Electrodes should not be reshaped or dressed with a rough file nor should their dressing be left to the discretion of the operator. The operator should be given a sufficient supply of electrode tips with instructions to change the tips when the above enlargement has been reached. Many troubles of excessive marking, burning or weak welds come from improper maintenance of size and shape of electrode tips.

There are many forms and shapes of electrode tips which can be used. The most common shape is the truncated cone or cone shaped tip. Other shapes commonly used which are a variation of this design are shown in Fig. 21. The electrodes tips are removable from the electrode holder, a conventional form of which illustrated in Fig. 22. This design uses tips having a taper, usually a Morse, the tips being removed by driving or twisting them out. A similar design uses threaded tips which may be easily removed with a wrench. This tip however, is more expensive and more subject to leakage.

The theoretical shape of the electrode tip would be spherical or ball pointed, the radius of the tip being determined by the kind and the thickness of the material. The use of this design is not so important in welding clean mild steel. It will be noted that the conventional design approximates the theoretical. Since the contact resistance is determined by the pressure, the contact resistance between electrode tip and work will be less for the theoretical shape than the conventional design because the unit pressure will be much greater on account of smaller contact area. During the welding period the softening of the metal being welded further decreases the contact resistance. If the area of the tip were very small excessive indentation would be obtained with this condition because of the high unit pressure. The spherical shape of the theoretical design offers a rapidly increasing area under this condition. The shape is more difficult to maintain but should be used where necessary.

It is often desirable to minimize indentation on one surface. Electrodes presenting a large area to this surface will produce the desired result. A large flat surface is commonly used. It is not possible however to eliminate entirely surface distortion and obtain a sound weld particularly when welding thin sheets. Many attempts have been made to eliminate this distortion and while it may be decreased to a negligible amount, it is an inherent part of the process and cannot be eliminated. The metals being welded are heated and forced together under pressure simultaneously, the electrodes preventing expansion of the metals against them. Thus the metals expand laterally when heated and upon cooling contract in all directions, causing distortions. By welding in short intervals the distortion may be lessened.

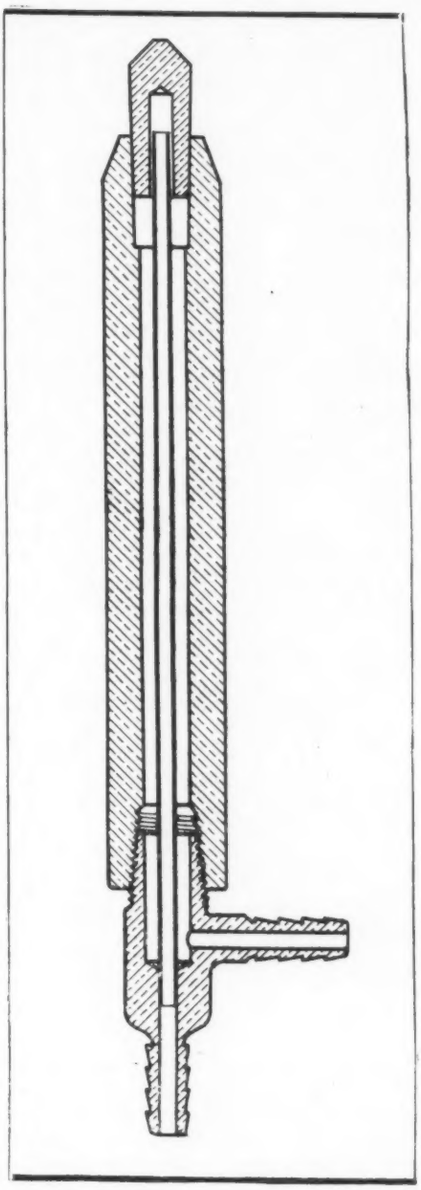


Fig. 22—Typical form of electrode holder

It has been indicated that an important function of the electrode is to conduct heat from the outer surfaces. Its ability to do this is determined not only by the thermal conductivity but also by the distance the heat must be conducted. The distance is determined by the cooling arrangement used. Fig. 22 shows the most common method and in this case the distance from the tip to the cooling water is short. Cooling water passes through a tube to within a short distance of the tip and returns between the electrode holder and the tube. Some designs of electrode holders

Table I—Characteristics of Copper Alloy Electrodes

	Per Cent Elect. Conductivity	*Per Cent Thermal Conductivity*	*Ultimate Strength lb. per sq. in.*	*Brinell Hardness*
Copper	100	100	30,000	35
Copper 15 per cent Hard drawn	98	98	35,000	90
Cadmium-Copper	85	90	61,000	120
Chromium-Copper	85	90	70,000	150
Tungsten-Copper	29	30	200,000	275

have employed solid tips with water cooling carried only as far as the electrode holder. Such a design is illustrated in Fig. 23. This design cannot be satisfactorily used in rapid production (more than 30 welds per minute), because the life of the tips will be short even when alloy tips are used. This design should be avoided on long runs.

Long, thin tips should be avoided for these same reasons. Fig. 24 show various arrangements of electrode holders and tips for unusual jobs or where welding must be done close to corners. Arrangements should be made so that sufficient cooling water will be available.

Many builders of welding machines specify the amount of cooling water required. Pressure and drain piping of sufficient size should be installed. Under most conditions ample cooling water is justified by the greatly increased life of electrode tips. It is not possible to obtain satisfactory high speed welding without ample provision for cooling the electrodes. The principal wearing parts

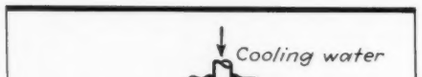


Fig. 23—Design of electrode holder suitable only for a low rate of production

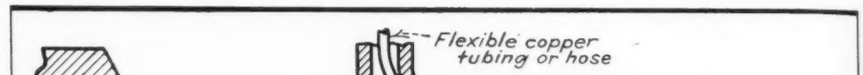

Flexible copper tubing or hose
Holder
Bent from holder of type shown in Fig. 22
Special offset tips with Fig. 22 holder at angle
Cooling water

Fig. 24—Various arrangements of electrode holders for unusual jobs or where welding must be done in close corners. Water cooling is carried into the tip

which require maintenance are the electrode tips and careful attention to these details will usually pay large returns, particularly on heavy production or where surface appearance is important.

The remaining factor which must be controlled during the welding process is the interval of time through which the current is allowed to flow. While the rate of development of heat is determined by the amount of current and the resistance (electrical) to the flow of this current; the quantity of heat will then be determined by the timing period. Therefore, accurate timing is necessary if a given quantity of heat is to be supplied for each weld. The control of this interval of time may be accomplished in several ways, such as:

1. Manually by judgment of operator.
2. Mechanically—as a part of the mechanical arrangement of the machine or by a separate timing device.
3. Electrically operated electronic or electro-magnetic devices or a combination of both.

The choice of the various types depends largely upon the desired result. There are jobs in which the judgment of the operator may be relied on and others where it is impossible for the operator to even estimate the proper timing interval. In general for production at a rate in excess of thirty welds per minute it is advantageous to use some form of mechanical or electrical timing.

The manual or non-automatic method has been described. Its advantage lies in its simplicity. The disadvantage is the possible variation in welds and in some cases it is impossible to get satisfactory results, as when short timing intervals required. Further, fatigue of operator may cause a variation in quality and quantity of welds throughout the working period.

The mechanical timing method has the advantage of simple mechanical arrangement and the elimination of the variable judgment of the operator. The disadvantage is that a cam must be adjusted when a different timing interval is required and the device is usually not sufficiently accurate on short welding times such as are often required.

To supplement the mechanical arrangement of motor driven machines, various types of electrically operated timing controls have been developed. It will be evident that a number of different arrangements may be used. However, the most common types use the time required to either charge or discharge a condenser. This method is extremely accurate. Another device uses the power developed by an electromagnet to displace a fluid at a predetermined rate. Another uses air to supply the necessary power.

Timers are designed either to provide a definite, constant timing interval or to automatically change the timing interval in response to variation in line current. Such variation may be caused by dirty or scaly stock, oxidized electrode tips, variations in line voltage, and other factors. The timer tends to interpret welding conditions and to supply a given amount of heat.

The electrically operated controllers may be classified in two general types:

1. Those controllers which use a magnetically operated switch (commonly called a contactor) to close and interrupt the main power circuit.
2. Those controllers which close and interrupt the main power circuit by means of electronic or vacuum tubes.

Here again the choice of proper control depends not only upon the welding time interval required, but also the cost of the installation. In general, the cost of the control using contactors is but a fraction of that using electronic or vacuum tubes. However, the shortest accurate timing when using magnetic contactors is 2 to 3 cycles based on 60 cycle supply. Various methods are being investigated which may result in decreasing this to $\frac{1}{2}$ or 1 cycle.

Electronic line interrupting devices are accurate to a fraction of a cycle and where the job demands this short time and accuracy they must be used.

The advantages of electrical timing controls are ease of adjustment, which is usually obtained from a calibrated dial; accurate timing; easily applied to any existing machine; and wide range and flexibility of adjustment. Principal disadvantage is the complication of the electrical equipment on the welding machine. But timing controls have proven themselves as an exceptionally trouble-free equipment and it is a common experience to obtain millions of operations without inspection or maintenance being required.

Air-operated machines require some type of electrical control to make the machine automatic in operation. The flexibility possible with this type of control has made many of the special machines possible.

In general, the operation of any machine will be improved by use of a timing control. For high-speed production and to obtain uniform results a timing control must be used.

DEFLECTIONS IN FRAMES

An Analysis Based on Strain Energy Equations

FRED M. COUSINS

Deflections in horizontal flat frames and chassis can be determined by a method which also compares the stiffening effects obtained when adding new cross-members to existing designs

FRAMED structures, such as car underframes, automobile truck, bus and passenger car chassis, and machinery, sub-bases, present some interesting design problems. Usually their rigidity in bending and in torsion are determined by conducting laboratory tests because a mathematical analysis is considered too complex.

The cost of laboratory tests are high but undoubtedly justified by the accuracy of the results obtained. However, much time and expense can often be saved by mathematical solutions to questions such as: How much will a given frame be stiffened by the addition of a cross-member? or How do the deflections in a given type of frame compare with those of a proposed frame of a different type?

In principle, most of the flat framed constructions which are made up of horizontal members are similar to either the cross-member type or to the x-member type automobile chassis frame.

PART I—Analysis of frames of the cross-member type.

To show a method of procedure, based on the application of Castigliano's first theorem, it is proposed to analyze a problem step by step and in so doing offer a means of direct comparison relative to the effect that each succeeding member has on the stiffness of the frame as a whole. In Fig. 1 is shown the usual set-up for an experimental analysis of some particular frame and in keeping with this particular set-up the mathematical analysis presented here will follow along the same lines.

Referring to the general set-up shown in Fig. 1 (a) the frame is firmly clamped at the rear at points *j* and *e*, supported at one front-end, at point *f*, and has a load *P* applied at point *a*. Fig. 1 (b) is a diagrammatic sketch to show the method of analysis, which is to split the frame into two separate units as shown, and to replace the reactions at the joints, for both the inner and outer systems, by forces equal to the reactions. The equation for the strain energy of each system is then written and the deflection at the points of application of the forces obtained by taking the partial differential coefficient of the strain energy of each system with respect to the particular force. The forces R, S, and T, are equal to the forces R_1, S_1, and T_1, respectively, and the deflections for both systems at points *b*, *c*, and *d* are equal. The axes are as shown in Fig. 1, the axes meeting at the point of application of the load and the notation used is apparent from the drawing.

EXAMPLE (1)

As a first step in the analysis consider the two side-frames *ae* and *fj* and the front cross-member *bg*, the load being applied at point *a*, and the outer system being the side-frame *ae*.

Equations for the outer system are:—

$$(1)\ \text{Strain Energy} = V_1 = \int_0^{L_1} \frac{(P\,x)^2\,dx}{2\,E\,I_{ab}} + \int_{L_1}^{L} \frac{[P\,x - R_1\,(x - L_1)]^2\,dx}{2\,E\,I_{be}}$$

$$(2)\ \text{Deflection at point } a,\ \delta_P = \frac{dV_1}{dP}$$

$$(3)\ \text{Deflection at point } b,\ \delta_{R_1} = \frac{dV_1}{dR_1}$$

Equations for the inner system are:—

$$(4)\ \text{Strain Energy} = V = \int_0^{W} \frac{(R\,z)^2\,dz}{2\,E\,I_{bg}} + \int_{L_1}^{L} \frac{(R\,w)^2\,dx}{2\,G\,(I_p)_{gh}}$$

$$(5)\ \text{Deflection at point } b = \delta_R = \frac{dV}{dR}$$

It is readily seen that the unknowns in the above equations are V, V_1, δ_P, δ_R, and the reaction $R = R_1$ at point *b*. The equations for obtaining these unknowns are five in number, therefore a solution can be effected. The deflections δ_R and δ_{R_1} are, of course, the same deflection, the deflection at point *b*. The width of the frame has been denoted by w and the subscripts for the terms I and I_p means that it is the moment of inertia of the particular part of the frame denoted by the subscript, I being the rectangular moment of inertia and I_p the polar moment of inertia of the section.

EXAMPLE (2)

As the next step in the analysis of the problem take the previous problem and add a second cross-member so that the problem becomes one in which there are two side-frames and two cross-members, one front cross-member and one intermediary. Following the same method as in the previous example and using the same notation the following group of equations is arrived at as representing the systems.

Equations for the outer system are:—

$$(1)\ V_1 = \int_0^{L_1} \frac{(P\,x)^2\,dx}{2\,E\,I_{ab}} + \int_{L_1}^{L_2} \frac{[P\,x - R_1\,(x - L_1)]^2\,dx}{2\,E\,I_{bc}} + \int_{L_2}^{L} \frac{[P\,x - R_1\,(x - L_1) - S_1\,(x - L_2)]^2\,dx}{2\,E\,I_{ce}}$$

$$(2)\ \delta_P = \frac{dV_1}{dP};\qquad (3)\ \delta_{R1} = \frac{dV_1}{dR_1};$$

$$(4)\ \delta_{S1} = \frac{dV_1}{dS_1}$$

Equations for the inner system are:—

$$(5)\ V = \int_0^{L_1} \frac{(R\,z)^2\,dz}{2\,E\,I_{bg}} + \int_L^{L_2} \frac{(R\,w)^2\,dx}{2\,G\,(I_p)_{gh}} + \int_0^{W} \frac{(S\,z)^2\,dz}{2\,E\,I_{ch}} + \int_{L_2}^{L} \frac{(R+S)^2\,w^2 dx}{2\,G\,(I_p)_{hf}}$$

$$(6)\ \delta_R = \frac{dV}{dR}$$

$$(7)\ \delta_S = \frac{dV}{dS}$$

An examination of the equations will show that there are the following unknowns: V_1, δ_P, V, R, S, δ_R and δ_S, seven in number, the same as the number of equations for effecting a solution. The reactions and the deflections at the joints are equal for the two sys-

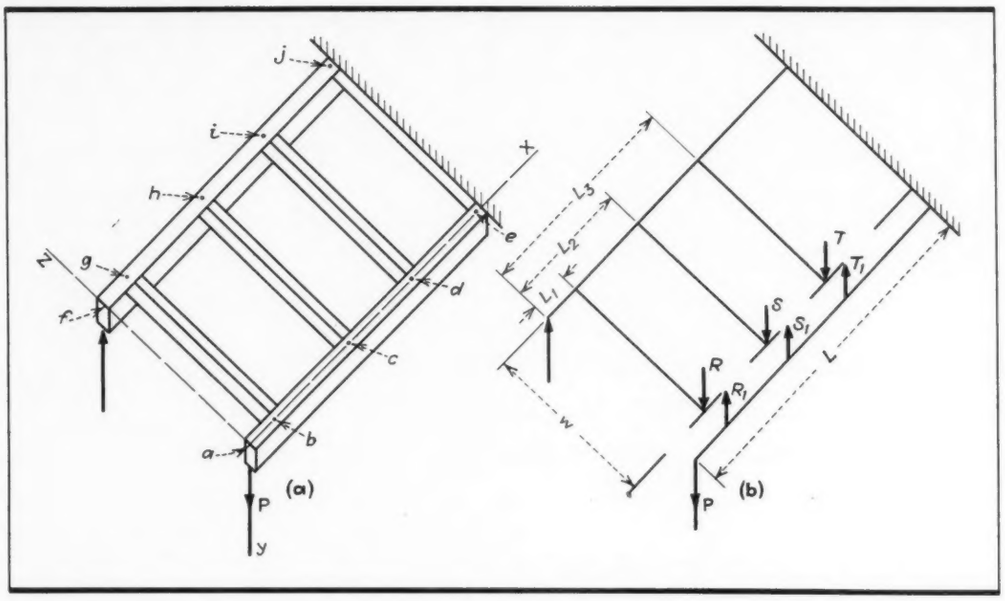


Fig. 1—(a) Cross-member frame clamped at rear of frame and supported at one front end with load applied at other front end (b) Diagrammatic sketch showing method of separating frame into two units for analysis

tems, that is, $R = R_1$ and $\delta_R = \delta_{R1}$, as before.

EXAMPLE (3)

As the final step in the analysis of the cross-member type of frame take the case where there are two side-frames and three cross-members, one front and two intermediary. The general equations for this particular case will be as follows.

Equations for the outer system are:—

$$(1)\ V_1=\int_0^{L_1}\frac{(Px)^2\,dx}{2\,EI_{ab}}+\int_{L_1}^{L_2}\frac{[Px-R_1(x-L_1)]^2\,dx}{2\,EI_{bc}}+\int_{L_2}^{L_3}\frac{[Px-R_1(x-L_1)-S_1(x-L_2)]^2\,dx}{2\,EI_{cd}}+\int_{L_3}^{L}\frac{[Px-R_1(x-L_1)-S_1(x-L_2)-T_1(x-L_3)]^2dx}{2\,EI_{de}}$$

$$(2)\ \delta_P=\frac{dV_1}{dP}\ ;\qquad (3)\ \delta_{R1}=\frac{dV_1}{dR_1}\ ;$$

$$(4)\ \delta_{S1}=\frac{dV}{dS_1}\ ;\qquad (5)\ \delta_{T1}=\frac{dV_1}{dT_1}$$

Equations for the inner system are:—

$$(6)\ V=\int_0^{W}\frac{(R\,z)^2\,dz}{2\,EI_{bg}}+\int_{L_1}^{L_2}\frac{(R\,w)^2\,dx}{2\,G\,(I_p)_{gh}}+\int_0^{W}\frac{(S\,z)^2\,dz}{2\,EI_{ch}}+\int_{L_2}^{L_3}\frac{(R+S)^2\,w^2\,dx}{2\,G\,(I_p)_{hi}}+\int^{W}\frac{(T_z)^2\,dz}{2\,EI_{di}}+\int_{L_3}^{L}\frac{(R+S+T)^2\,w^2\,dx}{2\,G\,(I_p)_{ij}}$$

$$(7)\ \delta_R=\frac{dV}{dR}\ ;\quad (8)\ \delta_S=\frac{dV}{dS}\ ;$$

$$(9)\ \delta_T=\frac{dV}{dT}$$

For this particular case V_1, δ_P, R, S, T, V, δ_R, δ_S, and δ_T are the unknowns.

PART II—Analysis of X-member type of frame.

Although the method of analysis is the same for the X-member type of frame as for the cross-member type, i.e., the application of Castigliano's theorem, greater consideration must be given to the X-member type because of the different characteristics that the center portion of the frame, the X-member, has which the cross-member type of frame does not have.

It is apparent from a study of the problem as shown in Fig. 2 that the rigidity of the frame, especially the center portion, will depend upon just how rigid the gusset plates are made. If the moment of inertia of the gusset plates about the axis of bending is made equal to or greater than the moment of inertia of the members comprising the

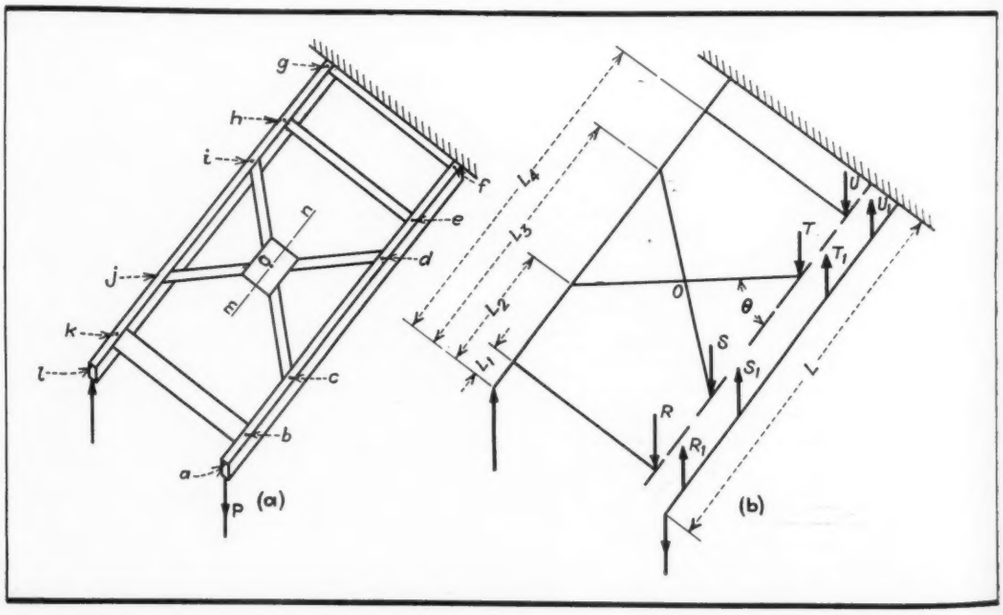


Fig. 2—The rigidity of the X-member type of frame especially the center position depends upon how rigidly the gusset plates are made

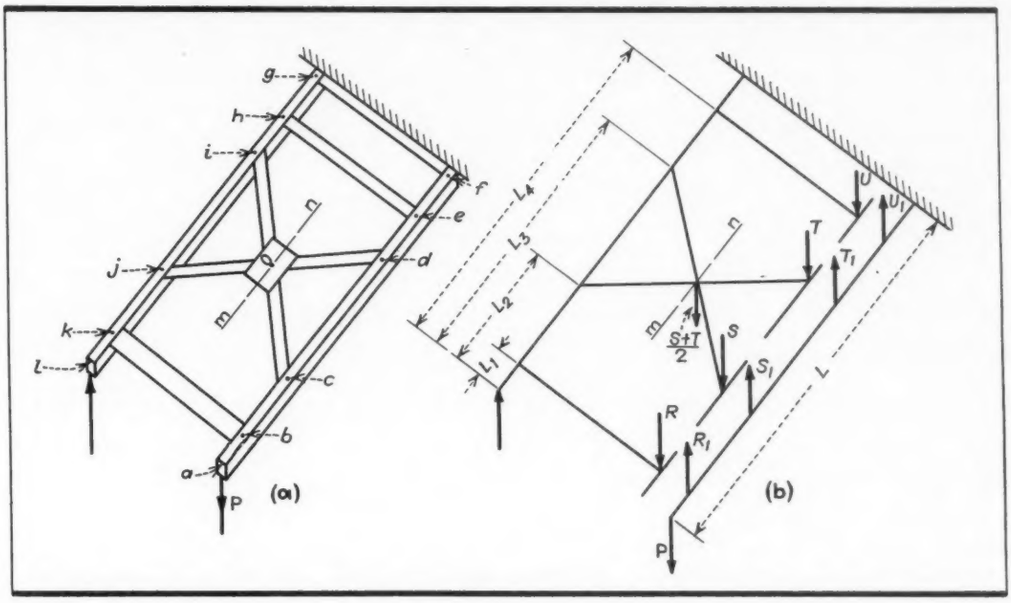


Fig. 3 — With inflection point at center of gusset plates in deriving the equations for the strain energy of the inner system, the average of loads S and T is placed at the intersection of the X-members

X-member, say *co* or *do*, then there will be a continuous load function through the members *ci* and *dj* and the X-member will act as a rigid frame. If this condition is not satisfied the X-member will divide itself into two separate units and there will be bending relative to the plane *mn*. The section *cdo* will act as one unit and the section *jio* will act as another unit.

EXAMPLE (4)

For the case where the X-member will act as a rigid frame the following equations are given.

Equations for the outer system are:—

$$(1)\ V_1 = \int_0^{L1} \frac{(Px)^2\,dx}{2\,EI_{ab}} + \int_{L1}^{L2} \frac{[Px - R_1(x-L_1)]^2\,dx}{2\,EI_{bc}} + \int_{L2}^{L3} \frac{[Px - R_1(x-L_1) - S_1(x-L_2)]^2\,dx}{2\,EI_{cd}} + \int_{L3}^{L4} \frac{[Px - R_1(x-L_1) - S_1(x-L_2) + N]^2\,dx}{2\,EI_{de}} + \int_{L4}^{L} \frac{[Px - R_1(x-L_1) - S_1\,(x-L_2) + N_1]^2\,dx}{2\,EI_{ef}}$$

in which

$$N = -T_1\,(x-L_2);\ \text{and}$$

$$N_1 = -T_1/(x-L_3) - U_1/(x-L_4)$$

$$(2)\ \delta_P = \frac{dV_1}{dP};\qquad (3)\ \delta_{R1} = \frac{dV_1}{dR_1};$$

$$(4)\ \delta_{S1} = \frac{dV_1}{dS_1};\qquad (5)\ \delta_{T1} = \frac{dV_1}{d\,T_1};$$

$$(6)\ \delta_{U1} = \frac{dV_1}{d\,U_1}$$

Equations for the inner system are:—

$$(7)\ V = \int_0^{W} \frac{(Rz)^2\,dz}{2\,EI_{hk}} + \int_{L1}^{L2} \frac{(Rw)^2\,dx}{2\,G\,(I_p)_{kj}} + \int_0^{W} \frac{(Sz)^2 \csc^2\theta\,dz}{2\,EI_{ci}} + \int_{L3}^{L4} \frac{(R+S+T)^2\,w^2\,dx}{2\,G\,(I_p)_{ih}} + \int_0^{W} \frac{(Tz)^2 \csc^2\theta\,dz}{2\,EI_{ji}} + \int_{L3}^{L4} \frac{(R+T)^2\,w^2\,dx}{2\,G\,(I_p)_{jt}} + \int_0^{W} \frac{(U\,z)^2\,dz}{2\,EI_{eh}} + \int_{L4}^{L} \frac{(R+S+T+U)^2\,w^2\,dx}{2\,G\,(I_p)_{ke}}$$

$$(8)\ \delta_R = \frac{dV}{dR};\qquad (9)\ \delta_S = \frac{dV}{dS};$$

$$(10)\ \delta_T = \frac{dV}{dT};\qquad (11)\ \delta_U = \frac{dV}{dU}$$

EXAMPLE (5)

For the particular case where there is an inflection point at the center of the gusset plates, point *O*, the usual procedure is as follows: Referring to Fig. 3, it will be seen that the set-up is the same as in Example 4, but with respect to the X-member the loads *S* and *T* at the joints *c* and *d* are continuous up to the gusset plate. The average of the two loads, $(S + T)/2$, is then placed at the point *O*, the load acting vertically, and the analysis of the section *jio* treated under this loading.

Although the number of unknowns and the number of equations for obtaining the solution are the same as in Example 4, it will readily be seen that the equation for the strain energy of the inner system is quite different. The general equations are as follows:

Equations for the outer system are:—

$$(1)\ V_1 = \int_0^{L1} \frac{(Px)^2\,dx}{2\,EI_{ab}} + \int_{L1}^{L2} \frac{[Px - R_1(x-L_1)]^2\,dx}{2\,EI_{bc}} + \int_{L2}^{L3} \frac{[Px - R_1(x-L_1) - S_1(x-L_2)^2\,dx}{2\,EI_{cd}} + \int_{L3}^{L4} \frac{[Px - R_1(x-L_1) - S_1(x-L_2) + N]^2\,dx}{2\,EI_{de}} + \int_{L4}^{L} \frac{[Px - R_1(x-L_1) - S_1(x-L_2) + N_1]^2 dx}{2\,EI_{ef}}$$

in which

$$N = -T_1[(x-L_2)$$

$$\text{and } N_1 = -T_1(x-L_3) - U_1(x-L_4)$$

$$(2)\ \delta_P = \frac{dV_1}{dP};\qquad (3)\ \delta_{R1} = \frac{dV_1}{dR_1};$$

$$(4)\ \delta_{S1} = \frac{dV_1}{dS_1};\qquad (5)\ \delta_{T1} = \frac{dV_1}{dT_1};$$

$$(6)\ \delta_{U1} = \frac{dV_1}{d\,U_1}$$

Equations for the inner system are:—

$$(7)\ V = \int_0^{W} \frac{(P\rho)^2\,dz}{2\,EI_{hk}} + \int_{L1}^{L2} \frac{(Rw)^2\,dx}{2\,G\,(I_p)_{kj}} + \int_0^{W/2} \frac{(Sz \csc\theta)^2\,dz}{2\,EI_{io}} + \int_0^{W/2} \frac{(Tz \csc\theta)^2\,dz}{2\,EI_{to}} + 2\int_0^{W/2} \frac{[(S+T)\ /\ 2\,(z \csc\theta)]^2\,dz}{2\,EI_{oj}} + \int_{L3}^{L4} \frac{[R+(S+T)/2]^2\,w^2\,dx}{2\,G\,(I_p)_{ih}\,4} + \int_0^{W} \frac{(Uz)^2\,dz}{2\,EI_{eh}} + \int_{L4}^{L} \frac{[R+U+(S+T)/2]^2\,w^2\,dx}{2\,G\,(I_p)_{ke}\,4}$$

$$(8)\ \delta_R = \frac{dV}{dR};\qquad (9)\ \delta_S = \frac{dV}{dS};$$

$$(10)\ \delta_T = \frac{dV}{dT};\qquad (11)\ \delta_U = \frac{dV}{dU}$$

HOW TO SELECT MOTORS

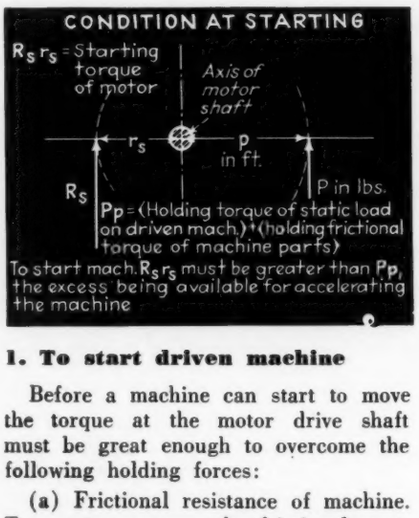
Part I—Analyzing Load for Torque Requirements

MARTIN SCHIFF
Chief Engineer, Century Electric Company

Factors governing the proper selection of motors are largely based on an analysis of the nature and magnitude of the machine load, and a consideration of type and size of motor which can deliver suitable torque-speed requirements at various stages of machine operation

THE FIRST step in the procedure leading up to the selection of a type and rating of motor to drive a given machine, is an analysis of the components which make up the loads on the machine. These components should be defined in terms of torque, or turning moment, and time so that they can be readily translated into terms of motor output required. Since the motor selected will be depended upon to start, to bring up to speed and to keep the driven machine running, the analysis of the loads on the machine divides naturally into three main parts:

STARTING TORQUE AND TIME REQUIRED TO START THE MACHINE


CONDITION AT STARTING
$R_S r_S$ = Starting torque of motor
Axis of motor shaft
r_S
P in ft.
P in lbs.
R_S
Pp = (Holding torque of static load on driven mach.) + (holding frictional torque of machine parts)
To start mach. $R_S r_S$ must be greater than Pp, the excess being available for accelerating the machine

1. To start driven machine

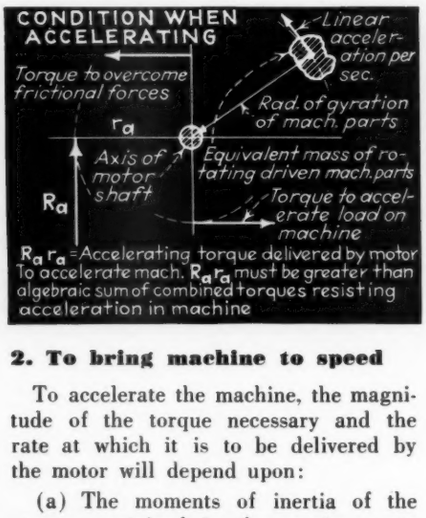
Before a machine can start to move the torque at the motor drive shaft must be great enough to overcome the following holding forces:

(a) Frictional resistance of machine. Torque to overcome the frictional starting resistance is usually best obtained by test. Such resistance will include bearing friction; resistance of chains, belts and cables to flexing; resistance offered by sliding parts, and other frictional losses.

(b) Resistance of connected load, if any. This will be zero at starting for machines where the load is not imposed until the machine has come up to speed. However, some machines such as compressors, piston pumps, and hoists may be required to start under full load. With this type of machine the resistance should be determined for the point of maximum starting torque in the machine cycle.

The motor torque delivered in excess of that required to overcome running friction at start plus starting load on the machine will be available for bringing the machine up to speed, that is, accelerating it.

ACCELERATING-TORQUE AND TIME REQUIRED TO BRING MACHINE UP TO SPEED


CONDITION WHEN ACCELERATING
Linear acceleration per sec.
Torque to overcome frictional forces
Rad. of gyration of mach. parts
r_a
Axis of motor shaft
Equivalent mass of rotating driven mach. parts
R_a
Torque to accelerate load on machine
$R_a r_a$ = Accelerating torque delivered by motor
To accelerate mach. $R_a r_a$ must be greater than algebraic sum of combined torques resisting acceleration in machine

2. To bring machine to speed

To accelerate the machine, the magnitude of the torque necessary and the rate at which it is to be delivered by the motor will depend upon:

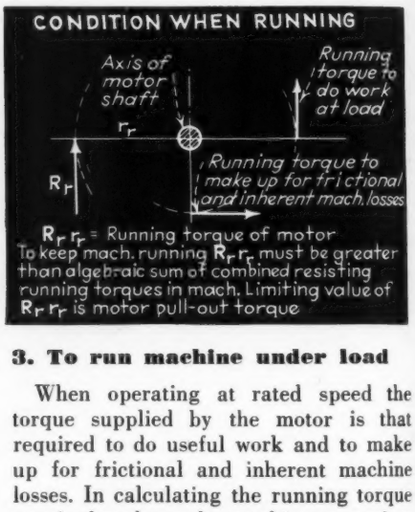
(a) The moments of inertia of the masses contained in the moving parts and their radii of gyration about or with reference to the motor axis. To avoid load pulsations, "flywheel" members, as in punch presses and compressors, having large masses are often added to make the load on the motor uniform. However, such additions to the inertia of the machine (or the WR^2) will correspondingly increase the accelerating torque which must be delivered by the motor. For a discussion of these factors see *Product Engineering*, Oct. 1934, "The Significance of WR^2 and How to Calculate It."

(b) Time allowed for acceleration—an important factor in determining the heat developed in the motor windings.

(c) Torque necessary to accelerate the load on the machine, if any is imposed before full speed is attained.

(d) Torque necessary to overcome resistances to acceleration offered by the frictional forces of machine parts.

RUNNING-TORQUE OVER TIME INTERVAL REQUIRED BY LOCAL CYCLES ON MACHINE

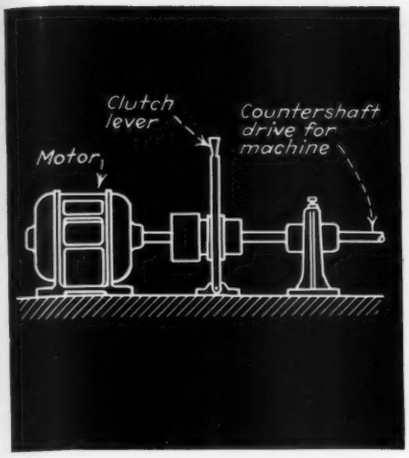

CONDITION WHEN RUNNING
Axis of motor shaft
Running torque to do work at load
r_r
R_r
Running torque to make up for frictional and inherent mach. losses
$R_r r_r$ = Running torque of motor
To keep mach. running $R_r r_r$ must be greater than algebraic sum of combined resisting running torques in mach. Limiting value of $R_r r_r$ is motor pull-out torque

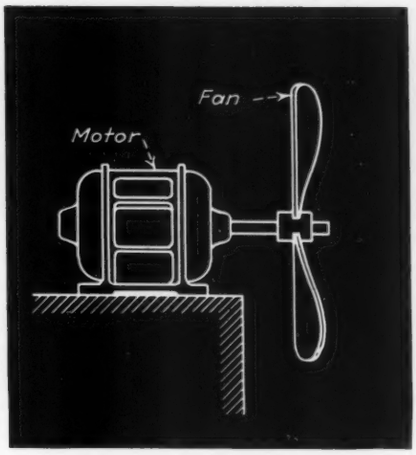
3. To run machine under load

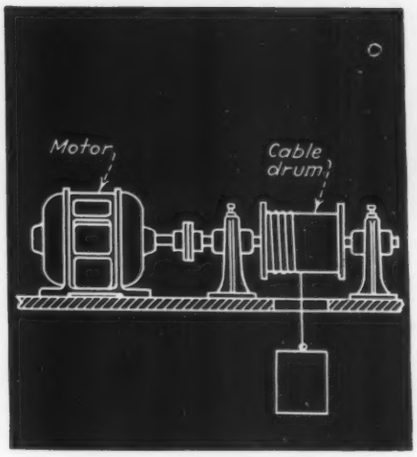
When operating at rated speed the torque supplied by the motor is that required to do useful work and to make up for frictional and inherent machine losses. In calculating the running torque required to keep the machine operating, it is well to add something on the safe side to take care of unexpected loads and circuit variations. It is poor practice to plan to use the excess torque that a motor can deliver over its nominal rating. Overloads cause rise in winding temperature and consequent depreciation in insulation properties which shortens motor life.

SUMMARY

If the procedure outlined in this analysis is followed the magnitudes of starting-torque, accelerating-torque and running-torque required by the machine can be determined and stated as so many lb.ft. or oz.in. referred to the motor shaft axis. With these data established the designer of the machine can state what he expects the motor to do and the motor manufacturer can specify in the same terms what the motor will do, as evidenced by its torque-speed performance curve.







4. Work-load applied after motor is running

With a disengaged clutch or unloading device between motor and machine the conditions at starting favor the motor since it is then free to start and to come up to speed against little resistance, for usually the torque required to start and accelerate the motor alone is negligible since frictional and inertia resistances of motor rotor and clutch parts are generally very small.

When clutch is engaged the machine load imposed on the running motor may be applied almost instantaneously if the clutch is of the jaw or the magnetic types, or the load may be applied to the running motor gradually over a short time range if the clutch is of the frictional or the spring separated plate type that permits slipping.

However, the ability of the running motor to start and accelerate the driven machine when the clutch is engaged is limited by a torque-value which will stall the motor, usually called the breakdown or pull-out torque.

If applying the machine load slows the motor an accelerating torque will be required of the motor to bring the machine up to the desired speed. Thereafter the machine load will determine the running torque required of motor.

5. Work-load applied as motor speed increases

When the motor is directly connected to the driven machine and the nature of the machine load is such that it increases as the machine speed increases from no load at rest to full load at full speed, as in fans, blowers and centrifugal pumps, the motor is required to deliver an accelerating torque which can accelerate the increasing load plus the torque required to accelerate the revolving masses.

At the instant of starting the inertia and holding torque of the machine may be small enough to be negligible. However, this should not be taken for granted, since dry bearings, cold lubricants, deflected shafting and sprung parts are factors which may set up considerable resistance to starting.

After the machine has begun revolving, at any instant the rate at which the machine accelerates will depend upon the relation between the motor accelerating-torque versus the WR^2 of the moving machine parts, plus frictional resistance, plus the load that is on the machine at that instant.

The running torque required of the motor after coming up to speed is mainly determined by the useful work done and the efficiency of the machine.

6. Work-load applied on the motor when starting

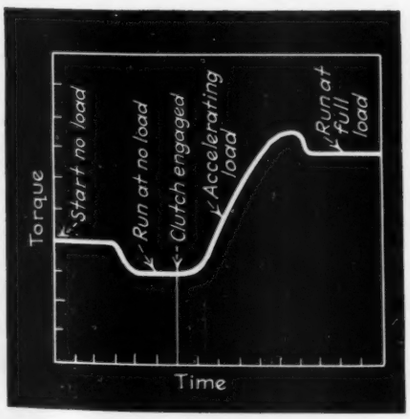
With the motor connected directly to a machine upon which a heavy work load must be encountered at instant of starting, such as in compressors and piston pumps without unloading devices, lifts and hoists, the torque required to start and to accelerate may be many times greater that that needed to keep the machine in motion after the desired running speed has been reached.

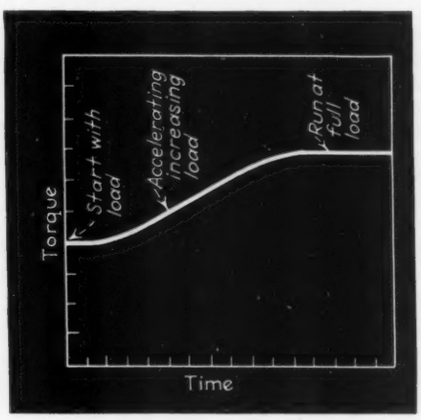
Especially is this so when the mass of the machine parts is large and their radii of gyration is great. The motor may be able to deliver enough starting torque to turn the loaded machine over slowly, but if the motor is not capable of delivering sufficient accelerating torque to bring the machine and load up to speed in a short time, heating will probably occur.

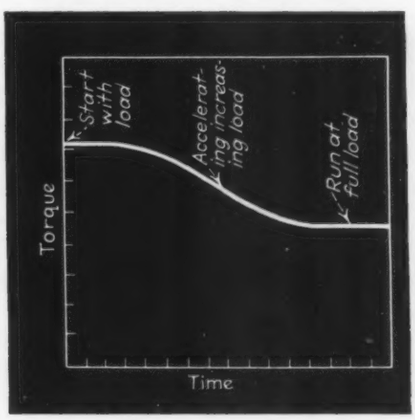
When the motor has to start and stop frequently under full load, the length of time of motor operation as compared to the idle time in the work or duty cycle is an important consideration that governs the generation and dissipation of heat.

Part II of this article will describe fractional horsepower motors, their torque-speed performance, and types of service to which they are inherently suited.

Figs. 7, 8 and 9—Torque-time load-curves on machines for load conditions as indicated in Fig. 4, 5 and 6 respectively







Question and Comment

Right Angle Motion Mechanism

To the Editor:

The right-angle-motion mechanism described by Mr. John E. Hyler in the Question and Comment department of the February number of *Product Engineering* arouses my interest. I should like, therefore, to comment on it if I may.

In the first place, Mr. Hyler's description of this device, while certainly clear enough, is not, I think, calculated to show its origin, or at any rate, its relation to other and better known mechanisms. Moreover, I do not believe that his mechanism would behave particularly well in practice.

Consider Fig. 1. Links 1, 2, 3, 4 shown in this figure constitute a well-known mechanism, called the 4-link double-slider linkage. For reasons that will appear presently, it is sometimes also called the Scott Russell straight-line mechanism. It will be noted that of these four links (1) link 1 is a base plate with two slots cut in it at right angles to each other, (2) links 3 and 4 are sliders or crossheads that slide in the aforesaid lots, (3) link or rod 2 is paired or jointed by turning pairs, 23 and 24, to links 3 and 4, respectively.

This 4-link mechanism possesses some interesting and useful properties, one of which is that any point rigidly attached to link 2 describes, relative to the base plate, an ellipse whose center is O. If, however, first, this point is attached to link 2 anywhere on the circle S_2 whose diameter is 23-24 and center C the ellipse described by the point becomes a special ellipse, namely, a segment of a straight line whose length is 2(23-24) and passes through center O. Secondly, if this point is attached to link 2 at C, the center of circle S_2, the ellipse described by the point becomes again a special ellipse, namely, a circle whose radius is OC and center O.

Since point C of link 2 describes a circle relative to link 1 whose radius is OC and center O we may remove link 4 and introduce in its stead link 5, as shown in Fig. 2. Links 1, 2, 3, 5 will then constitute a special case of the well-known slider-crank mechanism, so extensively used in steam and gas-engines. It is a special case of the slider-crank mechanism because crank 15-25 and connecting-rod 25-23 are, as we see from the figure, the same length.

Replacing link 4 with link 5 does not, of course, alter the fact that point P_2 of link 2 moves relative to link 1 in the straight-line path P_2-15. John Scott Russell (*1808-1882*), a distinguished Scotch engineer and naval architect, was the first person to notice this fact; hence the linkage 1, 2, 3, 5 is sometimes called Scott Russell's straight-line mechanism.

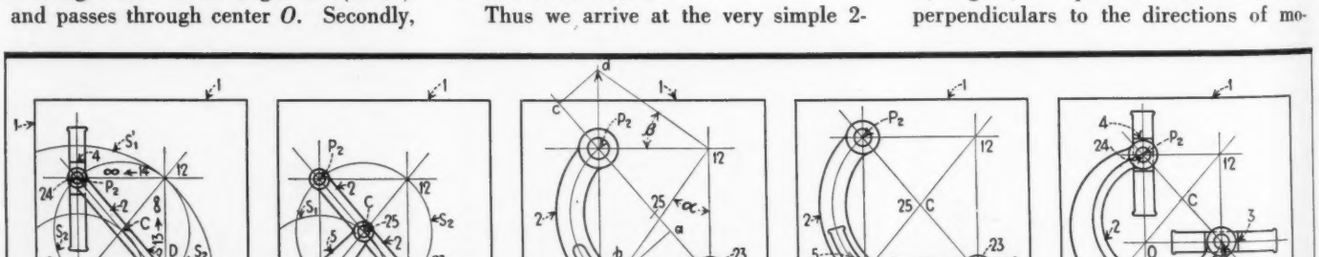
Now if point C (or 25) of link 2 moves relative to link 1 in the circle S_1 whose radius is 15-25 and center 15, then center 15 as a point in link 1 must move relative to link 2 in the circle S_2 whose radius is 15-25 and center 25. Therefore, in Fig. 3, link 5 may be replaced with a pin, fixed to link 1 at 15, working in a slot in link 2 of radius, 15-25 and center 25. It is evident, moreover, that crosshead 3, Fig. 2, may be replaced by a pin, Fig. 3, fastened rigidly to link 2 at point 23, sliding in a slot cut in link 1.

Thus we arrive at the very simple 2-link right-angle-motion mechanism described by Mr. Hyler. But the simplicity of Mr. Hyler's mechanism is purchased at the expense of durability since he replaces four lower pairs, pairs with surface contact, with two higher pairs, pairs with line contact. In other words, unless the forces acting in his mechanism are very light, wear between the cylindrical pins and the slots would be very rapid and the mechanism would soon become noisy and ineffective.

In most cases it would be better, therefore, to replace the pin at point 15, Fig. 3, with a curved slider and pin, Fig. 4, and the pin at 23 with a plane-sided slider and pin.

As a matter of fact, however, there is very little if any justification for either Mr. Hyler's device or for the modification of it that I have just proposed, because a much better way to effect his objective is shown in Fig. 5. The 4-link mechanism of Fig. 5 gives exactly the same relation between the motions of the driving and the driven points, 23 and P_2, respectively, as Mr. Hyler's device does, and it does so, it will be seen, without encroaching on the right-angle space that he desires to keep clear. Furthermore, it is free from the objection that wear in it would be rapid, and that binding would result if distance 23-O were short. I think, too, that it would waste considerably less energy in friction.

I am obliged, moreover, to find fault with Mr. Hyler's use of the term *instant center*, if by this term, as he uses it in his article, he means the center about which the member with the circular slot in it (I call it link 2) rotates at any instant. The instant center of this link is, Fig. 3, the point of intersection of perpendiculars to the directions of mo-



Mechanisms for transmitting straight line motion at right angles

tion of the driving and the driven points. In Figs. 1, 2, 3, 4, 5 it is thus point 12.

A word or two about the relation between the linear velocities of these two points may not be unwelcome to some readers. Designating the driving and the driven points with the symbols 23 and P_2, respectively, and their linear velocities with the symbols ${}_{23}V_{21}$ and ${}_{P_2}V_{21}$, we have, since the linear velocities of two points in the same rigid body are proportional to their distances from the center of rotation.

$$\frac{{}_{P_2}V_{21}}{{}_{23}V_{21}} = \frac{P_2\text{-}12}{23\text{-}12} \quad \ldots\ldots\ldots\ldots (1)$$

a formula with which the velocity of the driven point, P_2, can be calculated when the position of instant center 12 and the velocity of the driving point are known.

Or we may go from the known velocity of the driving point, 23, to the unknown velocity of the driven point, P_2, by a method that is entirely graphical, Fig. 3. There are many such graphical methods. The simplest one is perhaps that in which Rankine's principle of longitudinal components is used.

Let the vector 23-*b*, Fig. 3, represent the velocity of the driving point. Resolve 23-*b* along and at right angles to line 23-P_2. Make longitudinal component P_2c equal to longitudinal component 23-*a*. Draw *cd* at right angles to 23-P_2 and produce it to cut P_2-15 at *d*. Then P_2d is the velocity of point P_2 to the same scale that 23-*b* is the velocity of point 23. Component 23-*a* is, so Rankine said, equal to component P_2c because otherwise distance 23-P_2 would have to vary; but this distance cannot vary because points 23 and P_2 are points in the same rigid body.

A second and quite as convenient a way, when instant center 12 has been determined, to find graphically the velocity of point P_2 is to make angle *D* of right-angle triangle *b*-12-23 equal to angle β of right-angle triangle *d*-12-P_2, thus making the triangles similar and satisfying the relation of equation (1).

Mr. Hyler's statement that there is an instant during which the motion of the driven point is uniform is, of course, truistic if by the word *instant* he means an infinitely short period of time, because the motion of a point under any and all circumstances and at any time is uniform (or constant) for an instant. What Mr. Hyler means, I infer from the context, is that there is an instant, and a corresponding configuration of the mechanism, for which the speed of the driven point is equal to the speed of the driving point. And, of course, that is true, and such an instant occurs when these two points, Fig. 3, are equidistant from *O*, the center of the fixed pin; because then: (1) distances P_2-12 and 23-12, equation (1), are equal, and thus P_2-V_{21} = ${}_{23}V_{21}$; or (2) right-angle triangles 23-*b*-*a* and P_2cd are equal and therefore 23-*b*=P_2d.

Mr. Hyler makes—in the last paragraph of his article—still another statement that is provocative of criticism. He says there that the driven pin (pin P_2, Fig. 3) can be carried by a slider that moves in a slot cut in the baseplate, or, alternatively, that it can be left free, according as the forces acting in the mechanism are heavy or light, or according as deflection and chatter are present or absent. But when, it should be noted, the driven pin is carried by a slider, there is no occasion for the fixed pin at *O;* and if there is no pin at *O*, then what we have left is what is shown in Fig. 5, except for the difference in the two ways of carrying the driving pin in Figs. 3 and 5, of which the way shown in Fig. 5 is much the better for most purposes.

In conclusion I propose to those readers of Product Engineering who are interested in questions of mechanics of machinery this problem: Of the three kinematically equivalent mechanisms shown in Figs. 3, 4, 5 determine which is the least efficient for transmitting power from the driving point 23 to the driven point P_2.

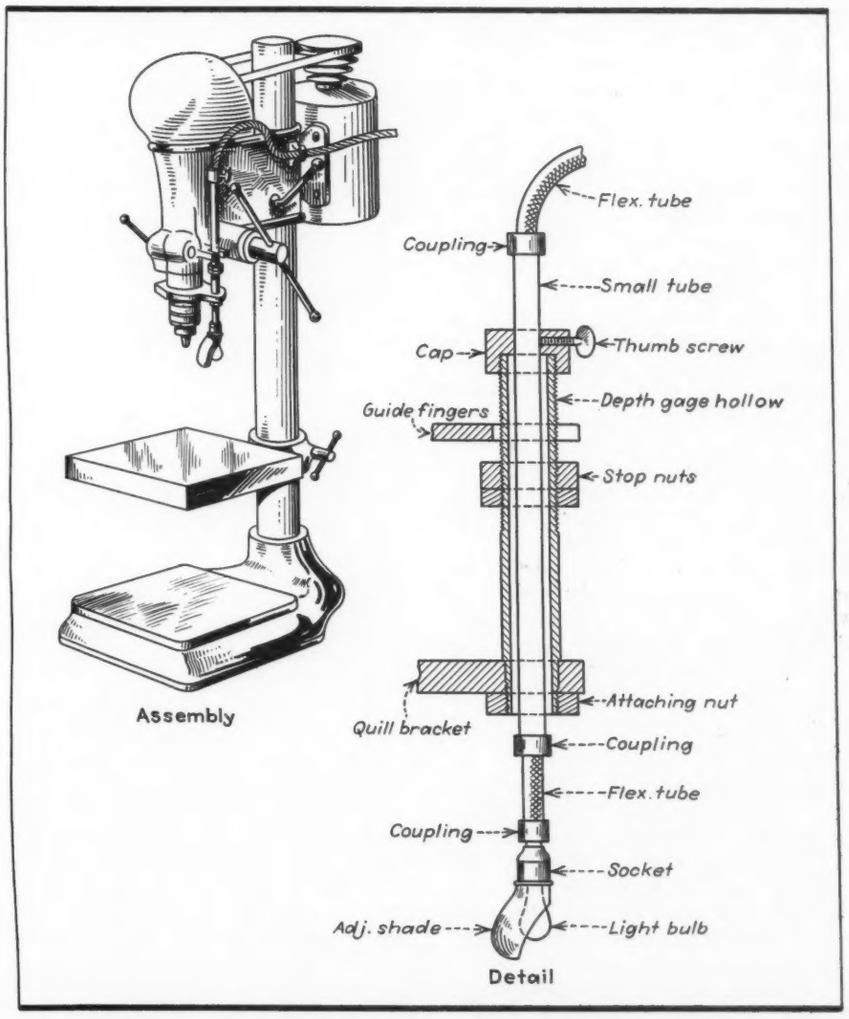
—WILLIAM H. RASCHE
Virginia Polytechnic Institute

"Designed-In" Lighting Unit

To the Editor:

In answer to the query of B. P. E. in the February number of *Product Engineering*, page 75, for an inbuilt lighting unit, I suggest the design shown below. An additional advantage of this arrangement for auxiliary illumination, is that the lamp may be adjusted independently of the drill and yet move with the drill in operation.

—J. W. NAYLOR
Niagara Falls, N. Y.



Inbuilt lighting unit to provide supplementary illumination as part of compact drill press

Source of Supply Wanted

To the Editor:

I should like to get information about a reversible gear box to use in connection with a felt cleaner for paper machines.

The felt cleaner is made to travel across the felt by means of a screw, and the rotation of the screw must be reversed by an automatic trip on a trip-rod. The trip-rod should, in turn, reverse the gears in order to cause the felt cleaner to work to and fro across the felt.

There are any number of gear boxes available for this purpose, but most of them are expensive and require considerable attention to keep them in working order. I am interested in one with low maintenance cost that is simple and easy to operate.

I should appreciate knowing whether or not said gear boxes are covered by patents. —L. L. LAPEYROUSE
Chickasaw, Ala.

How Many Teeth in Contact?

To the Editor:

With reference to J. J. G.'s inquiry in your March, 1938, number of *Product Engineering* about the number of teeth in contact in a pair of three-pitch, 24 tooth, 14½ deg. miter gears, the Lewis equation assumes that only one pair of teeth are in contact at any given time. For most gear ratios, more than one pair of teeth are actually in contact. The Lewis assumption allows for improper design, inaccuracy of manufacture and improper mounting. The miter gears in question are equivalent to spur gears having approximately 34 teeth and pitch diameter of 11.3136 in. The angle of action is approximately 22 deg., which gives an arc of action of 2.18 in. The pitch arc is 1.047 in. For these gears, therefore, the actual number of teeth in contact is slightly more than two, if they are perfectly formed and mounted.

If the material of which the gears are made is not given, it is impossible to determine whether or not they will transmit 1 hp. safely. —JAMES I. CLOWER
Virginia Polytechnic Institute

To the Editor:

With reference to J. J. G.'s inquiry in the March number of *Product Engineering* on *"How Many Teeth in Contact"* may I make the following comments?

The Lewis equation is based on the load being carried by one pair of teeth. This miter gear set is composed of gears having 24 teeth and assuming spur gears of the same number of teeth the contact ratio would be 1.600. For bevel or miter gears, of course, the contact ratio will be greater but for this number of teeth it will not be 2. In fact, if a 27 tooth spur gear was meshed with a rack, the contact ratio will be 1.947—a very good example to use as a comparison with the present problem. We can readily see that at no time will there be 2 pairs of teeth in contact.

These figures are, of course, based on rigid materials, whereas the materials we use yield somewhat under applied loads. However we should not assume a contact ratio larger than the theoretical one, as the amount of yield or tooth deformation is not a constant during the contact period. This is true because on the driven gear the contact begins at the tip of the tooth and moves in the direction of the root and, at the same time, the load carried by that particular pair of teeth changes as the position of the contact line changes.

In view of the above I would not assume the load being carried by more than one pair of teeth, hence the capacity of this drive should be rated as 0.6 hp., no more.

From the data given, however, the desired capacity is 1 hp. This particular drive, as far as the calculations are concerned, is not suited for duty in the proposed mechanism. This could possibly be corrected by studying the physical properties of the material used and using a larger stress factor. The factors used generally are too low and should be modified to agree with present day materials.

It is noted that the pitch-line velocity is 10.58 feet-per-minute. Because of this low value, the dynamic effects due to velocity would be negligible and the transmitted load at the pitch line could safely be assumed as the same as the static beam strength of the tooth as calculated by the Lewis equation.

—T. W. K.
Boston, Mass.

More on Gear Center Calculation

To the Editor:

The form given in the February issue is very interesting but I cannot find that Mr. Jordan can have any reason to be amused.

I admit some wizard will be able to calculate the given example in 12 minutes but I am sure he will not continue at the same speed for 8 hours a day for any length of time without wrecking his nerves. I assume that a good man at the machine will finish this calculation in about 30 minutes. The original layout in the August issue by Mr. Hinman contains about 10 times as much work as given in the form and would therefore need about five hours to complete. To this should be added two hours — one for checking and corrections the other for preliminary work, as the laying out of the different problems approximately to scale and as time for a general analysis of the computations to be done.

Thus it seems that seven (7) hours should be a fair time estimate if an electric calculating machine and good tables are available.

The form given by Jordan uses the same formula as Schemm, provided a printing mistake is corrected. In formula (1) as given by Schemm, R_1 should be given as "R_1"'. This formula gives the two numerical values of "y"; not the difference between the two values of "y" as the readers are led to believe by the way the difference "$y_{2\text{-}1}$" is shown in the sketch.

Although it is possible to do these calculations by machine only, I prefer to do many of them trigonometrically by the machine and recommend for this purpose the seven place "Natural Trigonometric Functions" by Robert E. Benson.

The principal dimensions of figure 2, which are claimed to be correct by Mr. Hinman, check within the practical limits of ±0.0002. —ERNEST VOYT
Detroit, Mich.

Rolling Qualities of Bevel Gears

To the Editor:

On page 120, March number of *Product Engineering*, F. F. J. asks for information regarding the free rolling of teeth of Bevel Gears.

It has been my experience that the 20 deg. pressure angle standard depth tooth for bevel gears and pinions, and the 20 deg. long and short addendum bevel gears and pinions possess better rolling qualities than either the 14½ deg. standard depth or the 20 deg. stub tooth gear and pinions.

The advantage of using the 20 deg. long and short addendum bevel gears and pinions is that the pinion is considerably stronger than the 20 deg. standard depth pinion. As to the question of greater end thrust pressure when using the 20 deg. gear and pinion, would say that this is unfounded in that the pitch angle of gear and pinion is the same regardless of the pressure angle used for any given case. The only effect that the pressure angle can have when using the 20 deg. instead of the 14½ deg. is to increase what is termed the "Separating Force." This force would tend to separate the gear and pinion, when not properly supported or mounted, much sooner than the 14¼ deg. gears. Present day practice however has taken care of this separating force by providing proper mounting and support for both gear and pinion.

—EDWARD J. RANTSCH
Hollis, N. Y.

Resistance Welding High Carbon Steel Wire

To the Editor:

I wish to thank Mr. Frost for his interest and to advise that the recommendations given in his letter in *Product Engineering* for April 1938 have already been tried without obtaining the desired results.

The wire to be drawn is high carbon steel wire containing 0.7% carbon and up. This wire is drawn on a continuous machine with five dies. The weld must, therefore, be strong enough to withstand drawing through all the dies; it takes an exceptionally good weld to withstand this. Trouble has been experienced by breakage at the weld occurring at the third, fourth, or fifth die. The following procedure has been tried. A small jig was made for filing the ends of the wire square in order to get a uniform butt. The weld was made and annealed immediately afterwards with a fairly high annealing heat at weld and a dull red heat each side, gradually running it down to a blue temper. Varying annealing heats have been tried but few welds have been able to go through to finishing die.

It would seem that, above a certain percentage of carbon content, about 0.64%, carbon, welds cannot be made to withstand the work required. I have heard of a method whereby welds have been made under a solution of carbon tetrachloride. I understand that this results in a less brittle weld since the solution seems to help in retaining some of the carbon and restoring the proper grain structure in the steel. Is Mr. Frost familiar with this method?

I would appreciate any further advice or information on this subject.—T. T. R.
Arlington, N. J.

To the Editor:

In reply to T. T. R.'s letter, published above, would advise that I have heard of the method of using carbon tetrachloride but, having never used it myself, I have no accurate information on what can be done by this method.

I note from T. T. R.'s letter that the high carbon steel wire contains 0.7% carbon and up. Such a wire may require rather exact heat treatment after welding in order to approach the original properties of the wire before welding.

As you know, when high carbon steel is heated to the plastic or liquid range and then cooled rapidly, as in the case of the resistance welding, the grain structure is changed into the grain structure which gives the hardest or most brittle tempering of the steel. In order to change this brittle grain structure, known as Martensite, to a more ductile metal having a grain arrangement such as sorbite or pearlite, it is necessary to heat the part of the wire which has been welded to a predetermined temperature and maintain this temperature for a length of time which depends upon the character of the steel. These factors cannot be determined without experiment for the particular steel.

It is, of course, reasonable to suppose that in order to return the metal to its original condition before welding, that it would be necessary to use the same type of heat treatment that was used on the wire in order to obtain its original grain structure. This may be obtained in different ways, and, in the case of some "patented" wires, special processes are used which would be difficult to duplicate after the welding operation has been made. It may be that the Metallurgical Department of the wire manufacturer can suggest the proper heat treatment process to be used to return the metal to its original condition. It would seem, however, that any attempt to duplicate the heat treatment as originally used would be a tedious and expensive process as applied to supplement the welding operation.

If every reasonable combination has been tried, I have only one or two suggestions. The first of these is to make sure that the annealing heat is maintained for a sufficiently long time. In the case of the steel T. T. R. is using, this may not be a matter of seconds but may require a minute or more. And second, reduce the area of the wire at the weld after the annealing operation.

The purpose of using the longer annealing time is that some steels require considerable time to permit rearrangement from the hard Martensite grain structure to the sorbite or pearlite. Since the difficulty in drawing this wire undoubtedly comes from the material in the weld being more brittle than the surrounding material, this material becomes even more brittle when cold worked in passing through the dies. Therefore, a reduction in the area will permit it to pass through the first die without being cold worked, and the character of the metal will begin to approach that of the surrounding material as the other is cold worked in passing through the die. This latter suggestion is, of course, a sort of a "last straw," and the preferred method would be to give the weld the proper treatment to return it to the original grain structure.

It must be remembered that while the rapidity with which a resistance weld is made is often a point in its favor, it can be one of the factors which necessitate the use of a different process because, in some cases, the very rapidity of the process makes drastic changes in the metal.

I suggest that T. T. R. make a complete run of tests beginning with short annealing times and running on up through annealing times of one or two minutes or more; then test each weld to determine the effect of this annealing time on the actual operation of the wire in coming through the drawing machine. In this way he will be able to determine whether annealing by his method will be satisfactory. If it is not satisfactory, T. T. R. can then use the shortest reasonably satisfactory time and try reducing the area at the weld until he obtains the proper balance of conditions at this point. By using the proper balance of the two, we believe he will be able to draw this successfully.

—L. H. Frost, *Welding Engineer*
The Electric Controller & Mfg. Co.

Can You Work This One?

H. E. SMITH

Solution to Last Month's Problem—

Tank Problem

If X equals the number of hours required to fill the tank, and Y equals the number of hours required to empty the tank, with the volume of the tank equal to V

Then $\frac{V}{X}$ = rate of inflow and $\frac{V}{Y}$ = rate of outflow.

Whence $\frac{V}{2}+\frac{12V}{X}-\frac{12V}{Y}=0$

And $\frac{V}{2}+\frac{15\,3/4V}{X+1}-\frac{15\,3/4V}{Y+1}=0$

By eliminating V,

$X = 8$ hours to fill tank
$Y = 6$ hours to empty tank

This Month's Problem—

Army and Messenger

A messenger at the rear end of an army 25 miles long runs up to the general at the front to deliver a message and then immediately returns to the end. During his trip the army is marching steadily. The messenger finishes his trip at the same point at which the general was when the messenger started his trip—that is, the army traveled 25 miles during his trip. How far did the messenger travel?

TYPICAL VARIABLE-SPEED TR

Mechanisms employing curved disks or cones for variable speed driving of heavy or light loads, covering various ranges of speed ratio

CYRIL DONALDSON
Rochester Athenaeum & Mechanics Institute

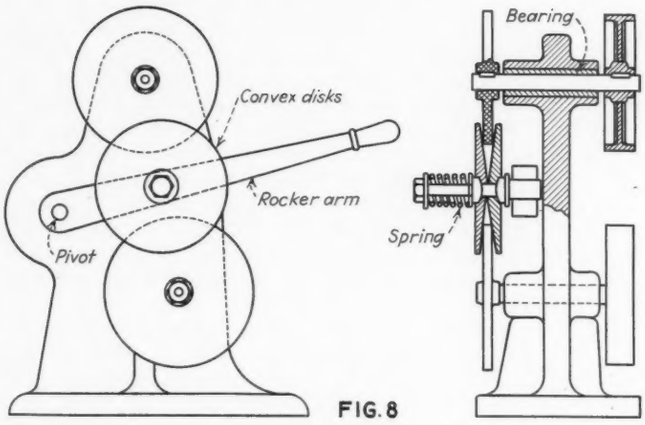


FIG. 8

FIG. 8—The well-known Sellers' disks consist of a device for transmitting power between fixed parallel shafts. Convex disks mounted freely on a rocker arm and pressing firmly against the flanges of the shaft wheels by a coiled spring form the intermediate sheave. Speed ratio changed by moving rocker lever. No reverse possible, but driven shaft may rotate above or below driver speed. Convex disk must be mounted on self aligning bearings to ensure good contact at all positions.

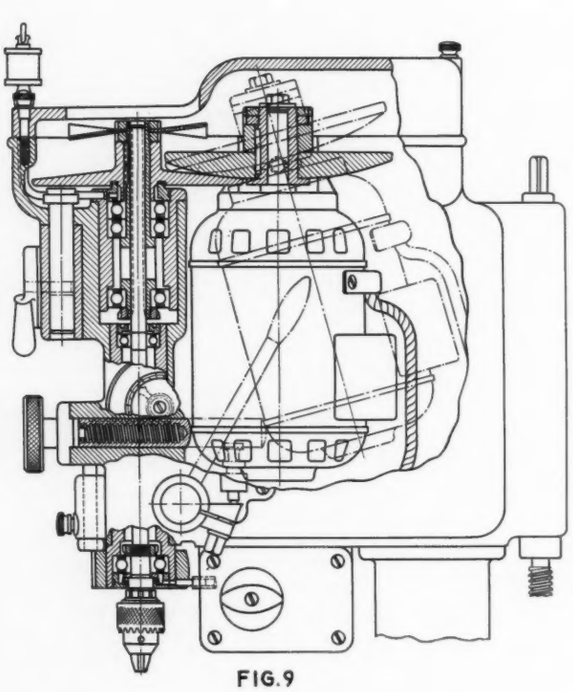


FIG. 9

FIG. 9—A curved disk device made possible by motorization. Motor is swung on its pivot in such a manner as to change the effective diameters of the contact circles. A compact drive for a small drill press.

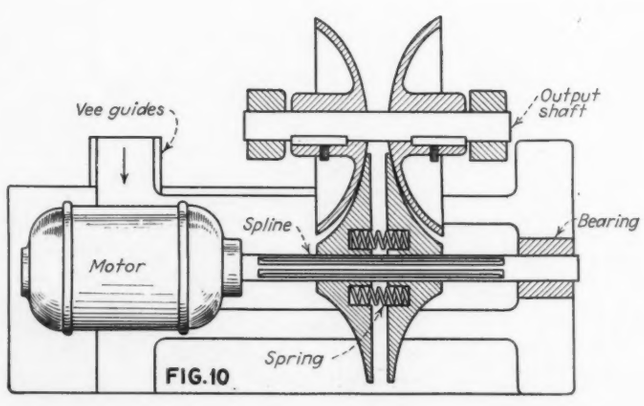


FIG. 10

FIG. 10—Another motorized modification of an older device. Principle similar to Fig. 8, but with only two shafts. Ratio changed by sliding motor in Vee guides.

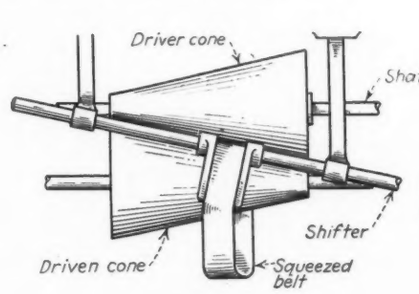


FIG. 11

FIG. 11—Two cones mounted close together and making actual contact through a squeezed belt. Speed ratio changed by shifting belt longitudinally. Taper on cones must be moderate in order to avoid excessive wear on sides of belt.

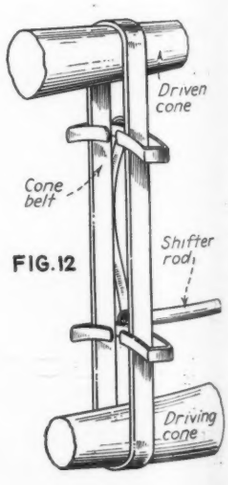


FIG. 12

FIG. 12—These speed cones are mounted at any convenient distance apart and connected by a Condor Whipcord belt, whose outside edges consist of an envelope of tough, flexible, wear-resisting rubberized fabric built to withstand the wear caused by the belt edge travelling at a slightly different velocity to the part of the cone in actual contact. Speed ratio changed by sliding belt longitudinally.

TRANSMISSIONS—II

FIG. 13—Another device to avoid belt "creep" and wear in speed cone transmissions. The inner bands are tapered on the inside and present a flat or crowned surface to the belts in all positions. Speed ratio changed by moving inner bands rather than main belts.

FIG. 14—Another device for avoiding belt wear when using speed cones. Creeping acting of belt not entirely eliminated, and universal joints present problem of cost and maintenance.

FIG. 15—An extension of the principle used in Fig. 14 whereby a roller is substituted for the belt, giving more compactness.

FIG. 16—The main component of this drive is a hollow cone driven by a conical roller. Speed ratio changed by sliding driving unit in Vee guides. Note that when roller is brought to the center of the hollow cone, the two run at identical speed with the same characteristics as a cone clutch. This feature makes system very attractive where heavy torque at motor speed is required in combination with lower speeds for light preliminary operations.

FIG. 17—In this transmission, the cones are mounted in line and supported by the same shaft. One cone is keyed to main shaft and the other is mounted on a sleeve. Power transmitted by series of rocking shafts and rollers. Pivoting rocking shafts and allowing them to slide changes speed ratio.

FIG. 18—This J. F. S. transmission uses curved surfaces on its planetary rollers and races. The cone-shaped inner races revolve with the drive shaft, but are free to slide longitudinally on sliding keys. Strong compression springs keep these races in firm contact with the three planetary rollers.

FIG. 19—Featuring simplicity with only five major parts, this Graham transmission employs three tapered rollers carried by a spider fastened to the drive shaft. Each roller has a pinion meshing with a ring gear connected to the output shaft. The speed of the rollers, and in turn, the speed of the output shaft is varied by moving contact ring longitudinally, thus changing the ratio of the diameters in contact.

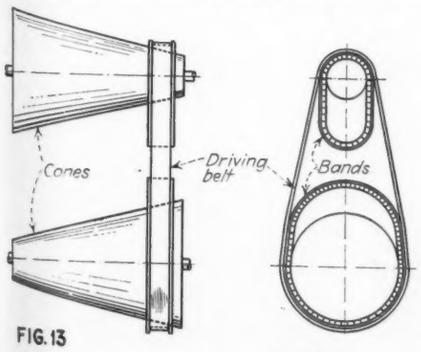


FIG. 13

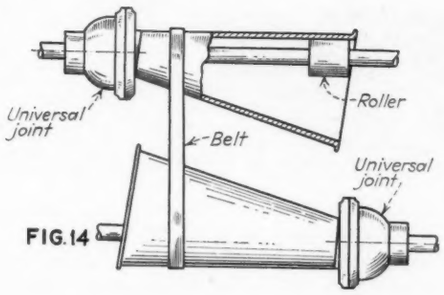


FIG. 14

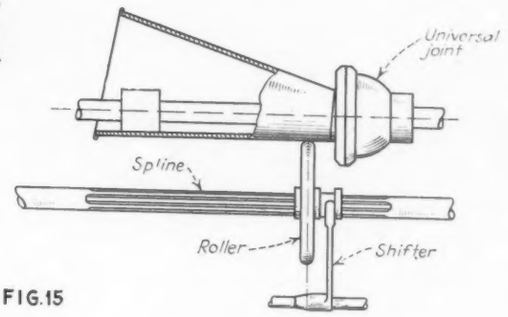


FIG. 15

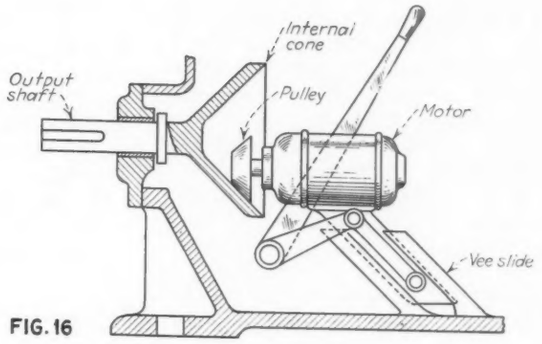


FIG. 16

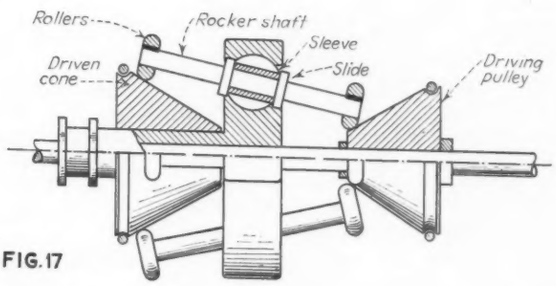


FIG. 17

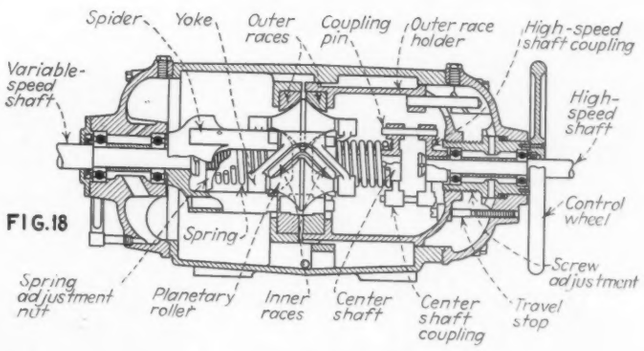


FIG. 18

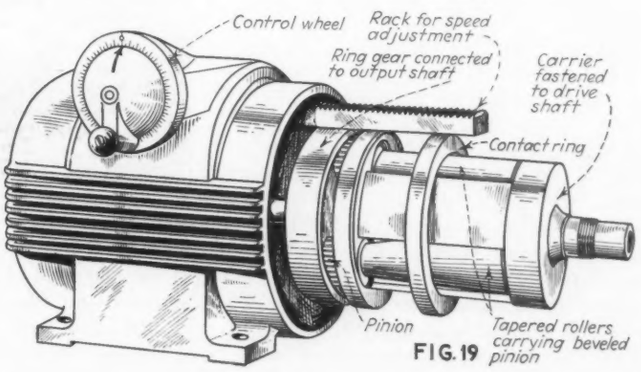


FIG. 19

News

1938 Foundry Convention

THE 42ND ANNUAL CONVENTION of the American Foundrymen's Association to be held at the Cleveland Public Auditorium, will open Monday morning, May 16, and continue four days to include Thursday, May 19, with the Foundry Show open for advance inspection on Saturday, May 14. The program includes 35 sessions comprising management, technical, production and shop practice, and round table conferences relating to steel, malleable, non-ferrous and gray iron foundry practice.

Steel division sessions will feature reports on the status of radiographic examination, coupon tests, heat-treatment and methods of producing steel. These will be supplemented by comprehensive papers on sand control in steel foundries, steel casting design, effects of aluminum additions and ductility values as affected by annealing.

An extensive series of papers on malleable iron will be devoted to annealing investigations, atmospheric control, short cycle malleable, and pearlitic malleable irons. Of the non-ferrous papers, a number discuss the role of silicon in non-ferrous castings, heat-treatment, and age-hardening. A committee report will present an analysis of defects.

Papers will be presented on the physical properties of cast iron in heavy sections, comparative effects of late additions of silicon and titanium to cast iron, and on molding and preparation of castings for enameling.

Magnetic Measurement of Coating Thickness

DEPENDING on the decrease in the attraction of a permanent magnet for iron when the two are separated by a non-magnetic coating, a rapid, non-destructive method for measuring the thickness of non-magnetic coatings, such as zinc, copper, tin, paint or enamel on steel is described in a paper by Abner Brenner, published in the *Journal of Research* for March.

The measuring instrument consists of a simple spring balance with a freely suspended magnet, which is calibrated with coatings of known thickness. It is possible to measure coatings up to 0.015 in. in thickness by means of this simple instrument.

Magnetic measurements of the thickness of commercial samples of plating, as compared with measurement of thickness by standard methods, gave an average erorr of plus or minus ten per cent for most coatings. The results for hot dipped thin coatings, which are usually only 0.0001 in. thick, are about 25 per cent low unless the instrument is calibrated against similar thin coatings. Nickel coatings on steel may be measured when a suitable calibration curve is used.

New Synthetic Rubber Plant

THIOKOL is now being manufactured at the new synthetic rubber plant of the Dow Chemical Co., Midland, Mich. The Dow company will henceforth produce all Thiokol synthetic rubber exclusively for Thiokol Corp., of Trenton, N. J. The only operation in the manufacture of Thiokol which is not being conducted at Midland is the production of the synthetic rubber molding compounds, which are vulcanized in Trenton, N. J. in the small plant adjoining the general offices and headquarters of Thiokol Corporation.

The necessity for enlarging the Thiokol plant at Yardville, N. J. made it expedient to erect the new plant as near to the raw materials source as possible. Dow Chemical Co. makes most of the raw materials which go into the making of this synthetic rubber and the new combination is as much a business move as one of needed expansion.

Sessions on Color

DISCUSSIONS of problems related to the measurement and application of color featured the recent meeting of the Inter-Society Color Council and the Optical Society of America, at Electrical Testing Laboratories, New York. The Inter-Society Color Council is a central clearing house supported by nine technical societies, including the Optical Society of America, and the Illuminating Engineering Society.

Dr. Deane B. Judd of the National Bureau of Standards presented a paper embodying recommendations for standard methods of designating color by the use of numerals in a code capable of telegraphic transmission and simple recording. Dr. A. C. Hardy of Massachusetts Institute of Technology discussed the Spectrophotometer, its design, construction and calibration and its application in industry. Construction and commercial production of the Spectrophotometer was described by Mr. J. K. Michaelson of the General Electric Company. Dr. K. S. Gibson of the National Bureau of Standards described the calibration of the machine that is installed at the Bureau and stated the limits of accuracy. The machine has

Interior view of Dow Chemical Co.'s new plant for manufacture of Thiokol, showing wash tanks, reactor, caustic measuring tank, dichlorethyl ether tank, ethylene dichloride tank, latex storage tank, coagulation tanks, sulphuric acid tank, with Thiokol drier at extreme right. Packages shown contain dried Thiokol

been found to be so sensitive and so accurate that it retraces a line on graph paper directly over a previous line and carries its range of reliable performance down to less than 1 per cent of the light received at any wave length. Carl E. Foss of the Research Laboratories of the Interchemical Corp., described the use of the machine in developing and standardizing printing inks, particularly for use in the three-color reproduction process.

A scientific presentation of the "Psychology of Color" was presented by Dr. Forrest Lee Dimmick, president of the Inter-Society Color Council and professor of Psychology at Hobart College. This talk was followed by discussions of the practical application of the psychology of color. The sessions were held in the building recently remodeled for the use of Electrical Testing Laboratories.

Glass Tape for Motor Insulation

TESTS ON MOTORS carrying heavy overloads and operating at high temperature are proving that tape made from fine strands of pure glass will withstand more severe operating conditions than other insulating medium. A number of coils insulated with this tape are installed in mine motors, motors on street cars and electric locomotives where they are successfully undergoing severe field tests.

Besides being fireproof, this tape adds to the life of the motor, surviving high temperatures without losing mechanical characteristics, its mechanical and dielectric strengths are high and it does not rot or decay. Glass tape is moisture and acid-proof, with high insulation resistance, and can be obtained in thicknesses as low as five one-thousandths of an inch.

Electronic Meter Measures 100,000 R.P.M.

MEASURING and controlling the speed of an ultra-centrifuge rotating at 100,000 r.p.m. is possible by a method developed by physicists at the laboratories of the United States Department of Public Health. The centrifuge used is driven by a compressed air stream and rotates on a similar stream for its bearing. Strobotac measurement did not permit accurate measurement rapidly, because the submultiples were too close together on the Strobotac scale, and provided no means for controlling the speed.

An electronic frequency meter indicates the speed in the new method. A beam of light, reflected from the surface of the rotating element, falls on a photoelectric cell. A black spot painted on the rotating surface interrupts the light once each revolution. The amplified output of the photocell is applied to the electronic frequency meter, which reads the speed directly in revolutions per second.

Automatic speed control is provided by a marginal relay in the d. c. meter circuit which regulates the pressure of the air stream driving the centrifuge.

Machine and Tool Progress Exposition

THE FIRST National Machine and Tool Progress Exhibition, which closed Saturday, March 12, held at Detroit, Michigan, attracted 23,755 visitors, of which less than 1,000 could be classified as "general public," according to Ford R. Lamb, executive secretary, the American Society of Tool Engineers, which sponsored the exhibition. Operating exhibits included several plastic molding machines, hydraulic power riveting installations, cross-axis rack machines, and progressive welding equipment. Plans for a repetition of the show in Detroit next year were announced by the A.S.T.E.

Large Atom Smasher Nears Completion

THE CYCLOTRON atom-smasher now under construction at Harvard University will be one of the largest of its kind in the world, and is expected to generate atom-smashing projectiles of 8,000,000 volt energy and above, permitting the most precise measurement ever made of the forces released by atomic disintegration. In the Cyclotron, ions are generated in a circular chamber between two flat, hollow, roughly semi-circular electrodes, supplied with high-frequency voltage from an oscillator. A strong transverse field from a powerful electromagnet, co-acting with the oscillating electrostatic field of the electrode, causes the ions to spiral out in the center of the chamber, receiving two accelerations for every turn of the spiral, until they emerge through the periphery of the chamber with high velocity, such as that produced by the older method with five or ten million volts.

Designers of the Harvard Cyclotron are Dr. Kenneth C. Bainbridge, Assistant Professor of Physics; Dr. Roger Hickman, Instructor in Physics and Communication Engineering; Dr. Harry R. Mimno; and Dr. Jabez C. Street.

New Standards for Bias-Cut Tape

STANDARDS for black and yellow bias-cut varnished cloth tape have been printed by the National Electrical Manufacturers Association. These standards cover dimensions of the tape, physical properties and manufacturing standards, ordering, inspection and rejection information. Copies of this publication, No. 38–50, may be obtained from NEMA headquarters, 155 E. 44th St., New York.

MEETINGS

AMERICAN SOCIETY OF MECHANICAL ENGINEERS — *National Meeting, Sagamore Hotel, Rochester, N. Y. May 10–12. C. E. Davies, secretary, 29 W. 39th St., New York.*

AMERICAN FOUNDRYMEN'S ASSOCIATION—*42nd Annual Convention, Cleveland Public Auditorium, Cleveland, Ohio. May 16–19. The Foundry Show will open Saturday, May 14, and continue to Thursday, May 19. D. Avey, secretary, 222 W. Adams St., Chicago, Ill.*

SOCIETY OF AUTOMOTIVE ENGINEERS—*Summer Meeting, The Greenbrier, White Sulphur Springs, W. Va., June 12–17. John A. C. Warner, secretary, 29 W. 39th St., New York, N. Y.*

AMERICAN SOCIETY OF MECHANICAL ENGINEERS—*Semi-annual Meeting, St. Louis, Mo., June 20–24. C. E. Davies, secretary, 29 W. 39th St., New York.*

AMERICAN SOCIETY FOR TESTING MATERIALS—*41st Annual Meeting, Chalfonte-Haddon Hall, Atlantic City, N. J., June 27– July 1. C. L. Warwick, secretary, 260 S. Broad St., Philadelphia, Pa.*

Do You Know That—

FIFTEEN BILLS to prohibit the patenting of labor-saving machinery or improvements thereof, have been introduced during the present Congress, according to *Research and Invention.* (77)

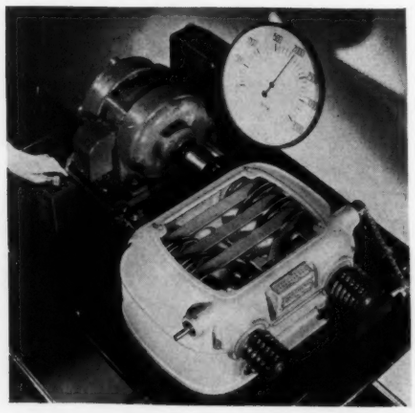
TOTAL WEIGHT of plastic materials manufactured in Great Britain amounted to 1.09 lb. per person, in the United States 1.45 lb. per person, and in Germany 1.5 lb. per person, the Society of Chemical Industry of Great Britain reports. (78)

HIGH CHROMIUM castings for stove plates installed on the cooking range of a plant cafeteria in 1933 are in perfect condition after four years of continuous operation. Ordinary cast iron covers and lids failed in about four months from oxidation and warping. These castings contained approximately 25 per cent chromium, small amounts of nickel and about 0.5 per cent carbon. (79)

New Materials and Parts

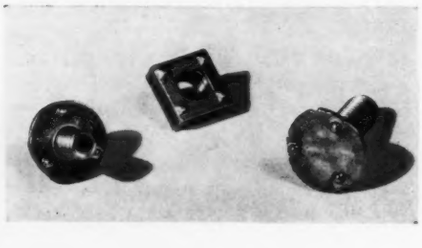
Vari-Pitch Speed Changer

A new speed changer unit which utilizes the principle of the multi-groove vari-pitch sheaves. The unit is totally inclosed, has double shaft extensions and is driven from a standard motor. For manual adjustment only, the unit is provided with a readily accessible handwheel control. However, the unit can be equipped for electric remote control or manual remote control. Range of capacity includes ratings up to 33 hp. with ratios as high as 3¾ to 1. Allis-Chalmers Mfg. Co., 1126 S. 70th St., West Allis, Wis.



Welding Nuts and Bolts

A line of nuts and bolts with small projections so that the nut or bolt can be assembled to a sheet by means of projection resistance welding. Two styles of welding bolts are available, one with the welding points or projections under the head and the other with the welding points on top of the head. The welding nut has four welding points or projections which are all of uniform height to insure a satisfactory distribution of the electric current through the points of contact. The nuts can be attached in places where brazing is rather impracticable. Blank nuts can be used to provide bearings of the through type or collar type for shafts or push rods. Nuts are available in stock sizes ranging up to ⅜ in. and larger sizes on order. Ohio Nut & Bolt Co., 600 Front St., Berea, Ohio.



Split Oil Seal

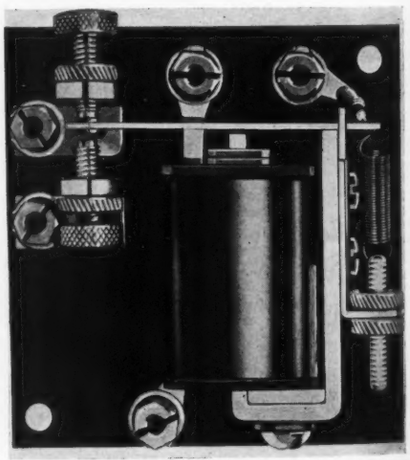
Known as Split-Klozure, this bearing seal is split or cut open so that it can readily be installed without the necessity of dismantling the machine. This sealing ring is made of the same Garlock compound as in their regular Klozures, being oil and heat resistant, does not absorb oil, and is highly resilient with a low initial coefficient of friction. Klozures are furnished regularly with steel springs but for water applications beryllium copper springs are supplied. Garlock Packing Co., Palmyra, N. Y.

Etching Solutions and Paste

A glass etch solution which will produce permanent white markings on glass and being very fluid it can be applied with a rubber stamp. It will dry rapidly with a small amount of heat. Also a metal etch solution for application with a rubber stamp to brass, copper and silver to produce a permanent black finish, drying rapidly in the air without heat. Also an acid glass frosting solution known as No. 2, which is in paste form and produces a fine grained white satin frost on any type of glass in 10 to 15 sec. It produces an unusually soft quality of surface. No. 1 safety frost solution for glass is also in paste form which produces a finish similar to that produced by solution No. 2 but requires treatment of the glass for 5 or 6 min. Being less corrosive, fewer precautions need to be taken in its use and the relative slowness of its action is an advantage where an article is to be immersed in the solution making it easy to obtain a uniform frost. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Sensitive A.C. Relays

These relays provide a high degree of sensitivity, good contact torque at pull-up and a crisp constant drop-out made possible by the use of nickel alloy in the magnetic circuit. Large knurled heads facilitate adjustments of the silver contacts and the spring tension on the armature. The relay is furnished with a molded plastic base and can be mounted in any position without affecting its performance. Available as single pole, double throw only. Ward Leonard Electric Co., Mount Vernon, N. Y.



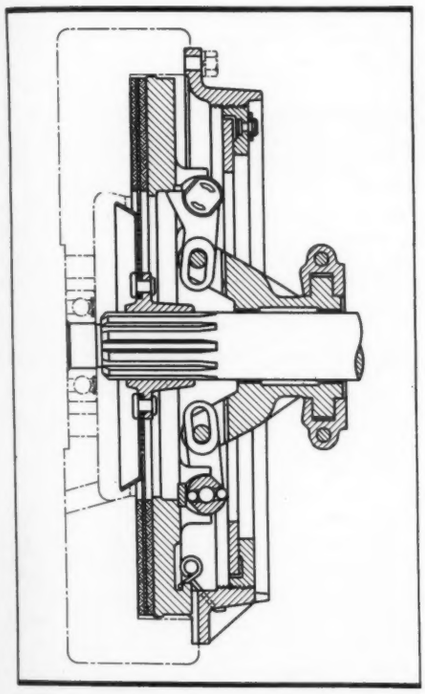
Manganese Steel Welding Rod

Marketed under the trade name Smootharc "Harmang," the electrodes are designed for welding parts subjected to heavy impact such as manganese castings, railroad frogs and crossings, dipper teeth and similar applications where both toughness and hardness are prime

essentials. Base metal of these rods is nickel manganese steel ranging from 11 to 14 per cent nickel manganese, 3½ to 4½ per cent nickel and carbon content in excess of 1 per cent. The slag coating stabilizes the arc and protects the metal against loss of carbon and manganese, but does not interfere with the rapid cooling required to form an austentitic deposit which, upon hammering or peening, becomes an extremely hard martensite layer. Rods are available in sizes from ⅛ in. to ¼ in., for use with 90 to 140 amp. current. Harnischfeger Corp., Milwaukee, Wis.

Over-Center Clutches

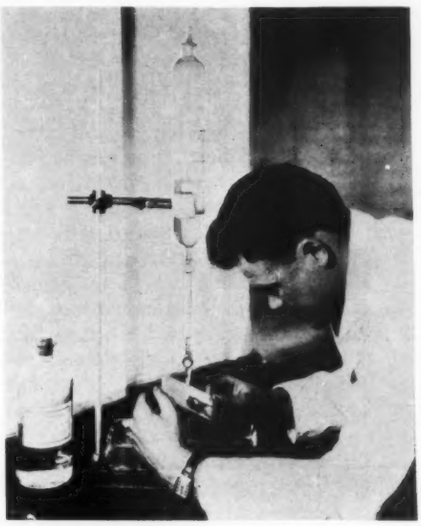
Improved design incorporating a new "roller cam" feature. Operation of the clutch is made evident in the accompanying illustration. The anti-friction roller



cams make operation of the clutch exceptionally easy and exert a heavy pressure symmetrically over the entire clutch face. Hardened and ground rollers bear upon the hard steel inserts in the pressure plate and on the hardened adjusting ring plate. Cam shafts are forged steel, operating sleeve has graphited bronze bushings, and fine adjustments can be maintained by positive locking means located near the outer diameter of the clutch and readily accessible through hand-hole in bell housing or cover. Made in sizes from 7 to 20 in. in diam. of faced driven member, 160 to 2,000 ft.-lb. torque, or 3 to 38 hp. per 100 r.p.m. Larger sizes are built to order. Rockford Drilling Machine Div., Borg-Warner Corp., 301 Catherine St., Rockford, Ill.

Test Set for Zinc Coatings

A zinc dropping test set for determining the thickness of electroplated zinc coating by the Hull and Strausser method. The principle of operation of this test set is the period required from the time a drop of the test solution



touches the zinc coated plate until the bare steel is exposed, the time being measured with a stop watch. Each second represents a thickness of 0.0001 in. An accuracy of within 10 per cent of the actual thickness of the deposit is obtained. Hanson-Van Winkle-Munning Co., Matawan, N. J.

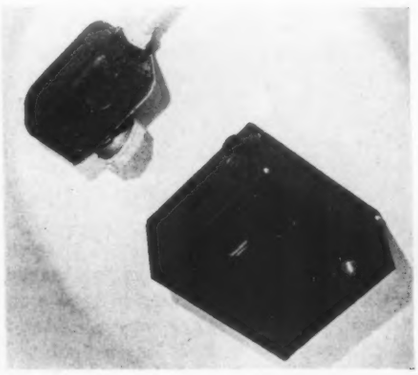
Variable-Speed Controller

A speed control unit combining a driving motor, a Reeves variable speed mechanism (and reduction gears where required) in a self-contained unit. Known as "Fluid Pressure Control," it can be used to automatically regulate speed according to pressure variation as in stoker feed on a boiler, maintenance of constant fluid pressure in a pipe line or tank upon which there is a variable demand, uniform tension between machine sections or between a machine and rewinder, and similar requirements. Can also be used as a manual remote control or as a semi-automatic manual control in different ways. Control consists of a

bellows operated shifting mechanism mounted on the Motodrive to which fluid pressure is transmitted by means of oil, water, steam, gas or air through an adjustable pressure reducing valve, through piping to the bellows shifting mechanism which operates to increase or decrease speed. Speed of shifting depends on fluid used. Air is fastest and will shift control over the widest (6:1) ratio through its complete speed range in 2 to 4 sec. Control is highly sensitive and responsive to slight changes in pressure. In largest unit, 5 lb. per sq. in. is required to start shifting from minimum speed, with 30 lb. per sq. in. required to attain maximum speed. Reeves Pulley Co., Columbus, Ind.

Photoelectric Control Units

Known as Model 50 photoelectric relay, this unit, complete with light source, is designed as a general purpose control suitable for many photoelectric applications. Operates only on 110 volt 60 cycles a.c., has internal telephone type relay with contact single pole, double throw, with a capacity of 2 amp. at 150 volts 60 cycles non-inductive current. Unit requires a minimum of 3 foot-candles on the photocell and impulses 1/20 of a second between each operation. Control has one RCA 6J5 amplifier tube and one UCC photocell 1105. Light source is a 32 cp. automobile type bulb to operate control at 25 ft. through a Bausch & Lomb 2 in. focal length lens. The light beams may enter two sides of the box, special knockouts being provided. The life of the vacuum tube averages about 3,500 hr., while the photocell should operate approximately 10,000 hr. The unit complete with light source lists for $24.75. United Electronic Industries, 43-37 Rawson St., Long Island City, N. Y.

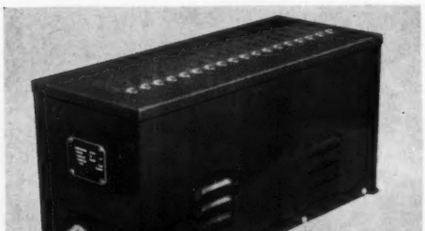


Synthetic White Enamel

White baking finishes known as KEM Appliance White Enamels, particularly suitable for appliances, furniture and general utility items. Leading features

of this enamel are given as: color stability under baking temperatures higher than usually feasible for white enamels, with tolerance of reasonable variations, thereby assuring a dependable color match. Its exceptional build and opacity makes possible a full rich finish and it is said to afford maximum resistance to discoloration under exposure to extremes of light, humidity, grease and usual chemical reagents. Also claimed to have excellent adhesion and hardness, with high resistance to impact, marring and wear. These enamels are offered in both high and intermediate baking types. Sherwin-Williams Co., Cleveland, Ohio.

Automatic Voltage Stabilizer



Designed to provide constant a.c. voltage for equipment such as X-ray machines, color comparators, photo-printing devices, photo-meters, amplifiers used in talking motion pictures, radio transmitters and similar apparatus. This regulator is capable of stabilizing a.c. voltages that may vary from 95 to 130 volts, holding it constant at 115 volts plus or minus 1 per cent, automatically and instantaneously. It is a magnetic device without moving parts or adjustments and can be made to operate from any commercial a.c. power source and deliver one or more required voltages with power outputs up to several thousand voltamperes. Designed to be built into the apparatus as original equipment, making them free from manual voltage adjustments. Raytheon Mfg. Co., 133 Willow St., Waltham, Mass.

New Blueprint Paper

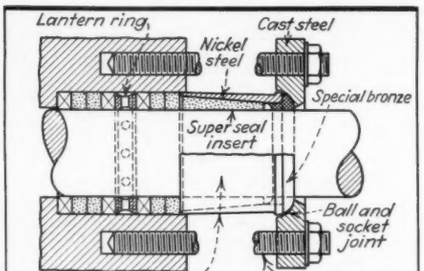
A new line of blueprint papers, known as Series Sixty, that is said to have a remarkably wide printing range and an unusually deep blue color so that the white lines of the reproduction stand out in sharp, legible contrast. An outstanding advantage is that tracings of varying opacity can be reproduced successfully at a single machine setting. Available in two types, Parchmine and Challenge. Keuffel & Esser Co., Hoboken, N. J.

Wood Pulp Conduit

A line of wood pulp fiber conduits ranging in size from 3 to 6 in. I. D. in various wall thicknesses. Also elbows, fiber adapters, reducers and other fittings. This conduit is said to have exceptional strength, toughness and a high dielectric strength with a smooth clean surface finish. Brown Co., Portland, Me.

Self-Aligning Packing Glands

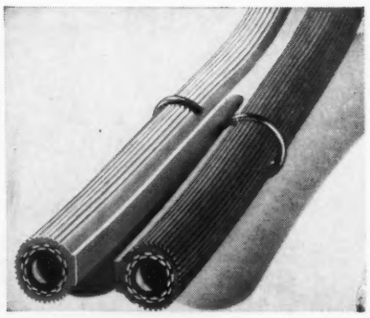
A conical, self-aligning packing gland adapted for reciprocating pumps and engines, and compressors for handling ammonia, air, propane and other gases and liquids. Construction details and materials are shown in the illustration. Gland cup is packed with "John Crane" Super-Seal split packing inserts moulded to fit the gland. Tapered inner surface of cup forces the packing around the rod with each stroke of the piston. The ball and socket construction compensates for float and prevents wedging or



distortion of the cup when it meets the cast steel follower, should the studs be drawn up unequally. Any size or shape of follower may be obtained to fit existing dimensions or conditions, although the two-stud type is most generally recommended. Crane Packing Co., 1800 Cuyler Ave., Chicago, Ill.

Double Rubber Hose

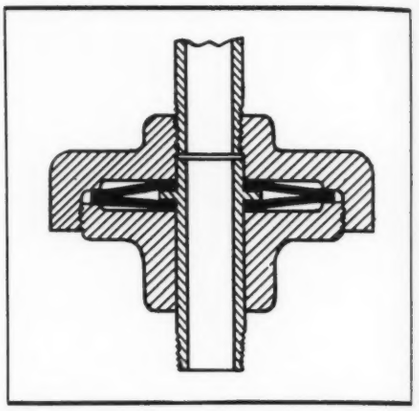
Two lines of high quality, two-braid hose, joined together by an integrally molded web, known as Electric-Siameez. This hose is said to offer exceptional flexibility and the added



strength of two layers of tightly braided reinforcement. Hose is recommended especially for welding and cutting operations for working pressures up to 200 lb. per sq. in., the cover of the hose being made especially thick and tough to withstand drag over hard rough surfaces. Available in ¼, $\frac{5}{16}$ and ⅜ in. sizes and, when specified, the ends are separated at the factory to prepare the hose for attachment to the equipment. Electric Hose & Rubber Co., Wilmington, Del.

Packless Sealing Unit

Basic principle of the unit is shown in the sectional illustration where it is shown applied to a pipe or shaft. A spring steel wafer fits over a machined



collar on the shaft or tube. The wafers being spring steel they form a close, uniform contact against the faces of the shoulder when their outer edges are pressed together, thus forming a pressure seal. This packless unit can be used where a float movement is to be transmitted to valves or switches, to operate mechanisms inside of a vessel or vat from an external lever, to provide a swivel pipe, a pressure joint or stuffing box. The unit is available as a self-contained flanged assembly as illustrated and in a number of other standard and special forms in a range of sizes. Jas. P. Marsh Corp., 2073 Southport Ave., Chicago, Ill.

Sheet Metal Finish

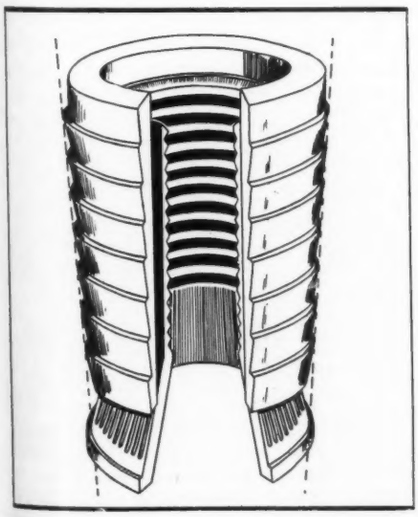
A new specialty finish developed primarily for office furniture and business machines, known as S-W Satin-Glo. Is said to produce a finish of pronounced beauty, luster and mar-resistance in one coat. Also resistant to severe abrasion, perspiration, chemical and cleaning soaps. Satin-Glo is available in two spraying and two dipping qualities and is offered in olive green and other colors if quantity requirement justifies special runs. Sherwin-Williams Co., Cleveland, O.

Oil-Proof Pushbutton Stations

Especially designed for machine tool applications, this new line of low-priced, compact, standard-duty pushbutton stations are provided with a graphited packing ring between the pushbutton proper and the bushing or oil guard. This packing ring is to prevent the seepage of oil or grease from the operators' gloves or hands into the pushbutton mechanism, thereby making these pushbutton stations especially resistant to the deteriorating action of oil and dirt. The line includes flush or surface mounted, momentary contact and selector switch units. General Electric Co., Schenectady, N. Y.

Anchor for Machine Screws

Known as "Rawls," for anchoring machine tools in concrete, stone or brick, this anchoring device is of a special lead alloy, tapered in shape with rows of grooves. The machine threaded nut is of malleable iron for sizes of 5/16 in. and larger and brass for smaller sizes. A chamfer helps to align the screw when inserting it. Available in sizes from 6x32 in. to 5/8x11 in. The Rawlplug Co., Inc., 98 Lafayette St., New York, N. Y.



Shielded-Arc Welding Rods

A complete line of shielded-arc welding electrodes, claimed by the manufacturer to be quieter in operation, faster in welding time, produce finer bead appearance and have greater adaptability per rod with no changes in customary operating practice required. Line includes "all-position" welding electrodes, "flat-position" and "fillet-welding" electrodes, general-purpose fillet-welding electrodes, electrodes for a.c. transformer welding machines, light sheet metal electrodes, a general purpose electrode for welding mild steel and cast iron welding electrodes. McKay Co., Pittsburgh, Pa.

Hollow Screw Wrenches

These wrenches resemble a detachable head of a socket wrench, but in place of a socket to fit over the screw head, they have a protruding hexagonal driver that fits into the hollow screw. Ten sizes of driver fit all screws from

1/4 to 1 in. diam. The set illustrated, AL-100, consists of ten wrenches, two reversible ratchets, three sliding T-handles, two extensions and an adapter. Wrenches, handles and extensions are of chrome-vanadium tool steel and the reversible ratchets are drop forged with hardened steel gears. All wrenches and parts are chrome plated. Armstrong Bros. Tool Co., 317–357 N. Francisco Ave., Chicago, Ill.

Across-The-Line Starters

A new manual across-the-line type starter and a new a.c automatic across-the-line starter. The new manual across-the-line type motor starter, Bulletin 2851, has thermal overload protection with pushbutton operations. A depression in cover of the steel inclosure prevents accidental contact. A new mechanism operates silver-to-silver butt type contacts. The new a.c. automatic across-the-line type motor starter for non-reversing service, Bulletin 4002, illustrated, is provided with thermal overload protection, pushbutton operation and a three-position selector switch in the cover. On "automatic," the starter can be operated only from remote control station or pilot device. In "off" position, the starter is inoperative. In "hand" position, the starter operates immediately and stays in running position until switch is turned to "off" position. Ward Leonard Electric Co., Mount Vernon, N. Y.

New Resin Adhesive

A new resin adhesive known as 5116, which is a synthetic resin of the phenolic type. Is thermo-plastic and is supplied in solution in a hydro-carbon solvent. It is applied exactly as is the average glue, no heating or extreme pressure or curing being necessary. The liquid is simply spread in a thin film, allowed to air dry to a tacky state and the two parts are then placed together under sufficient pressure to give a uniform bond. Drying and hardening is affected by the evaporation of the hydro-carbon solvent. The resulting bond is claimed to be exceptionally tough and strong and to possess an unusual resistance to alkalies. Bonding strength is retained to temperatures up to 100 deg. C., the softening point occurring between 115 and 120 deg. C. Typical applications include bonding asbestos to metal, bonding treated paper and cellophane wrappings to wire, bonding cellulose acetate and rubber for bonding molded plastic parts. General Plastics, Inc., North Tonawanda, N.Y.

Adjustable V-Belt Sheaves

A new series of 2-groove adjustable pitch diameter V-belt sheaves for speed variation up to 33 per cent. Known as "Texsteel" these sheaves are available

in three sizes, namely, 2 to 3 in., 2.5 to 3.5 in. and 3.5 to 4 in., these dimensions being the extremes of pitch diameter. To change pitch diameter the motor must be stopped, belt tension relieved, the locking screw loosened and the adjustable plate rotated to give the desired pitch diameter. Can be used for loads up to 3 hp. Allis-Chalmers Mfg. Co., Milwaukee, Wis.

Friction Tape

A new kind of tape in addition to their regular Slipknot black friction tape, known as Slipknot brown. It is claimed to be the first basic improvement in the tape industry in many years, having longer life than any other commercial tape now on the market. Plymouth Rubber Co., Canton, Mass.

Manufacturers' Publications

BEARING MOUNTINGS—R-S Products Corp., 4530 Germantown Ave., Philadelphia, Pa. Bulletin B-50, 12 pages, 8½x11 in. Describing "Standard Appliances for Anti-Friction Bearing Mountings," covering the standardized housing covers, closures, slingers and housings, and other parts for use with a wide range of bearing types and sizes. Numerous tables of standard dimensions for such units are included.

BEARINGS—Johnson Bronze Co., New Castle, Pa. Catalog 380, 64 pages, 8½x11 in. An illustrated listing containing complete data on 800 stock sizes of Johnson general purpose bearings, 350 sizes of bronze cored and solid bars and more than 200 sizes of electric motor service bearings. Listed in both alphabetical and progressive sizes.

BLUEPRINT PAPER—Keuffel & Esser Co., Hoboken, N. J. Catalog, 12 pages, 5¾x8¾ in. Describing their new line of blueprint papers known as Series Sixty, the feature of which is exceptionally deep blue color.

CABLE—Anaconda Wire & Cable Co., 25 Broadway, New York, N. Y. Publication C-41, 36 pages, 8½x11 in. Descriptive data, applications and physical and electrical properties of Anaconda varnished cambric cable. Also includes a series of new tables of recommended thickness of insulation, tests and new current capacities data for use of this cable in both air and ducts. Recommended instructions for making straight joints on varnished cambric cable are given in the concluding section.

CABLE—General Electric Co., Schenectady, N. Y. Bulletin GEA-2623, "Varnished-Cambric Insulated Cable," 32 pages, 8½x11 in. Containing information on available types of varnished-cambric insulated cable, their construction and characteristics, and the applications for which they may be best adapted. Also includes simplified data on how to select conductor size.

FIBER PRODUCTS—Brown Co., Portland, Me. Booklet, 25 pages, 8¾x11¼ in. Describing the Bermico conduit manufactured from wood pulp. Physical characteristics of the conduit, standard weights and sizes and standard fittings are given in various tabulations. Application data and method of installation is also included.

HEATING ELEMENTS—Acme Electric Heating Co., Boston, Mass. Catalog E, 60 pages, 8½x11 in. Describing grid heating elements, cartridge heaters, space heaters, liquid immersion heaters and other types. Also, hot plates, stoves and ovens using them.

HEAVY DUTY PUSHBUTTONS—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. Catalog, 8 pages, 8½x11 in. Describing their type HD line of pushbuttons for heavy-duty service on a.c. and d.c. pilot circuits, with specification tables, dimensional drawings and price list.

LUBRICATION—Bijur Lubricating Corp., Long Island City, N. Y. Bulletin G, 12 pages, 8½x11 in. Presenting a series of recent Bijur advertisements which have appeared in technical and trade journals, featuring the automatic, centralized system of pressure lubrication pioneered by Bijur.

METAL COATING PROCESSES — Calibron Products, Inc., 51 Lakeside Ave., West Orange, N. J. Calibron Notebook No. 4, 24 pages, 6x9 in. Following a review of present methods of coating metals with metals, a new coating development, the "Martin Process," is outlined. The booklet also contains a discussion of the diffusion of metals and gives notes on iron-aluminum-chlorine reactance.

METAL MOULDINGS—Dahlstrom Metallic Door Co., Jamestown, N. Y. Catalog, 7th Edition, 175 pages, 9x11 in. Drawings and specifications covering a wide range of Dahlstrom mouldings and shapes. Catalog is divided into eight sections classifying the various types of mouldings according to their use.

MOTORS—Barber-Colman Co., Rockford. Ill. Data Sheet M-11. Covering the dimensions and performance characteristics of their two-pole uni-directional and reversing motors.

MOTORS—U. S. Electrical Motors, Inc., 1500 S. Western Ave., Chicago, Ill. Two new bulletins: "Streamline Protection" describes their standard horizontal "Uniclosed" motor and shows the method of ventilation provided in U. S. motors. "Asbestos Protected" describes the method used in insulating and winding their motors.

NEEDLE BEARINGS—The Torrington Co., Torrington, Conn. Booklet, 12 pages, 9x12 in. Presenting reprints of a series of informative advertisements on Torrington needle bearings for which the company was cited in the Annual Advertising Awards.

PACKINGS—Crane Packing Co., 1800 Cyler Ave., Chicago, Ill. Folder 8½x11 in. Illustrations and concise descriptions of Crane packings for reciprocating and centrifugal hot and light oil pumps with hard and medium hard steel plungers, valve stems, etc.

PIPE—A. M. Byers Co., Pittsburgh, Pa. "Wrought Iron for Piping Systems," 40 pages, 8½x11. A discussion of the commonly used pipe materials, costs, and their selection for specific types of service. An appendix is devoted to statistical data regarding the life of various pipe materials in specific installations. Another bulletin covering "Welding of Wrought Iron" is also available.

PLATED FINISH—Special Chemicals Corp., Dept. E, 30 Irving Place, New York, N. Y. "Facts About Spekwite," 12 pages, 3½x6 in. Setting forth the qualities and uses of "Spekwite," a low-cost tarnish-resistant white plate.

PRE-FINISHED BONDED SHEETS—American Nickeloid Co., Peru, Ill. Booklet, 32 pages, 9x12 in. Complete technical data on pre-finished American bonded metals, including pre-finished sheet stock with colored coatings. Includes many striking application pictures and also tables of properties and sizes, standard gages and weights, and a table to assist in their selection.

PUMPS—DeLaval Steam Turbine Co., Trenton, N. J. "DeLaval Pumps for All Purposes," 15 pages, 4x9 in. Descriptive data, photographs and sectional views setting forth the special features of various types of DeLaval pumps.

PUMPS—Narragansett Products Corp., 45 Baker St., Providence, R. I. Leaflet, 8½x11 in. Illustrating and describing their "Midget" coolant pump.

RELAYS, SWITCHES, STARTERS—The Clark Controller Co., 1146 E. 152nd St., Cleveland, Ohio. Bulletin 7322 contains technical data on their a.c. mill type thermal overload relays. Bulletin 101 covers their heavy-duty master switches for mill and crane service, Type RD. Bulletin 6013 covers their a.c. automatic starters.

SPEED NUTS—Speed Nut Div., Tinnerman Stove & Range Co., Fulton Road, Cleveland, Ohio. Folder, 6 pages, 8½x11 in. Illustrations and brief descriptions of a variety of speed nuts and their applications in many different industries.

SPEED REDUCERS—Winfield H. Smith, Inc., Springville, Erie Co., N. Y. Catalog describing the complete line of WHS speed reducers suitable for transmitting from fractional to 75 hp.

WELDING—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. Booklet, "New Profits from Resistance Welding with Ignitron Split-Second Control," 12 pages, 8¼x10¾ in. Covering Westinghouse ignitron controls with suggestions for handling unusual welding jobs needing frequent heat adjustment for different current and time values.

Books and Bulletins

Internal Combustion Engines

HOWARD E. DEGLER. *400 pages, 6x9 in. Clothboard covers. Numerous illustrations. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York, N. Y. Price $4.00.*

Following a review of thermodynamics, the chemistry of fuels and combustion, and mechanics, covering about 100 pages, the author devotes five chapters to typical automobile and aircraft engines, vaporizing oil engines, heavy-duty diesel engines and high-speed diesel engines. In each of these chapters are shown numerous cross-section views of typical engines, typical constructions, and performance curves.

Four separate chapters are devoted to the design of combustion chambers; fuel injection systems; design of cylinders, cylinder heads, crankshafts, engine frames, connecting rods and other engine parts; ignition systems and auxiliaries. The last two chapters cover engine testing and the economics of gas and oil power. A twenty-page appendix presents the A.S.M.E. test code for internal combustion engines.

Written primarily for use as a textbook, problems are included at the end of each chapter.

Index to A.S.T.M. Standards

128 pages, 6x9 in. Paper covers. Published by the American Society for Testing Materials, 260 S. Broad St., Philadelphia, Pa.

The latest index to the A.S.T.M. standards and tentative standarls as of January 1, 1938. These include specifications, methods of testing, recommended practice, definitions of terms, charts and tables.

Metal Airplane Structures

MAJOR FLAVIUS E. LOUDY, *Aeronautical Engineer. 455 pages, 6x9 in., 284 illustrations and charts. 68 tables. Blue cloth binding. Published by the Norman W. Henley Publishing Co., 2 W. 45th St., New York, N. Y. Price $5.00.*

Practical treatise on the design and construction of major component parts of various American and foreign airplanes, covering the entire field of airplane metal structures with special emphasis on the theory and practice used in monocoque design. The text is comprehensively illustrated with diagrams, charts and photographic reproductions showing important design points of the various structures. Numerous tables and formulas are also given to aid the engineer in the design of structural members and joints.

The book is divided into eleven chapters covering: types of metal airplanes, materials of construction, structural elements, welded joints, riveted joints, stressed skin design, types of metal wings, metal wing beams, wing design, fuselage design, hull and float designs, each of which is treated in detail.

Graphic Routes to Greater Profits

JOHN W. ESTERLINE. *320 pages, 8½ x11 in. Brown fabricoid covers. Published by the Esterline-Angus Co., Indianapolis, Ind. Price $3.00.*

A book on the use of graphic instruments in increasing the productive capacity and efficiency of industry. The text is divided into 240 case studies, each covering a distinct problem, giving the procedure followed, the graphic charts obtained and an explanation of the solution reached.

The introductory section is made up of three chapters, "The High Cost of Inefficiency", "What Graphical Representation Means", and "Classification of Industrial Problems." The remainder of the book, consisting of case studies, is in five divisions, "The Problems of Power", "The Problems of Machines", "The Problems of Practices", the "Problems of Men", "Research and Special Problems." The case studies throughout the 19 chapters are numbered serially and cross-indexed.

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Simple Methods of Analyzing Plating Solutions

FOURTH EDITION, *1938. 36 pages, 4¾x7¼ in. Published by Hanson-Van Winkle-Munning Co., Matawan, N. J.*

Describing the methods in commercial practice of analyzing electroplating solutions of all commercial metals, including nickel, brass, cadmium, copper, chromium, gold, silver, tin and zinc, for all of the important commercial constituents.

Influence of Design on the Stress Resistance of Steel Castings

By the late MAJOR R. A. BULL. *Reprint No. 37-35, 62 pages, 6x9 in. Published by American Foundrymen's Association, 222 W. Adams St., Chicago, Ill. Price 35 cents.*

The first portion of the paper deals with the basic principles of steel casting design and with the development of the steel casting industry with reference to design of such castings. The author then discusses, among others, the effect of design on solidification rates, the value of tapering sections on ease of production, design of castings that must be heat-treated, the influence of sharp corners, the difficulties inherent in designs containing light and heavy sections, the symmetrical proportioning of casting members, the influence of design in causing local hot spots and in causing tears.

Titanium in Cast Iron

E. R. STARKWEATHER. *Reprint No. 37-37 from the Transactions of the American Foundrymen's Association, 222 W. Adams St., Chicago, Ill.*

The subject matter of this paper covers: a brief story of the element titanium and its occurrence; a review of the results of investigations by well-known authorities; the various attributes of titanium and its effect upon the physical properties of iron, including recommended procedure for handling; and the treating of electric furnace iron with titanium.

Welding Instructions and Standards Part I

Loose-leaf booklet, 81 pages, 8½x11 in. Published by the United States Steel Corporation Subsidiaries, 434 Fifth Ave., Pittsburgh, Pa. Price 50 cents.

This booklet, the first of a series dealing with all phases of welding, is concerned primarily with methods of showing welding on drawings by the American Welding Society's new symbol system. A supplement to Part I briefly discusses standard sections of welds, filler metal properties, workmanship and other subjects not directly connected with the section on welding symbols.

Tests of Strength Properties of Chilled Car Wheels

FRANK E. RICHART, REX L. BROWN AND PAUL G. JONES. *70 pages, 6x9 in. Paper covers. Bulletin No. 294, Engineering Experiment Station. Published by the University of Illinois, Urbana, Ill. Price 85 cents.*

Results of an investigation to determine the strength properties of chilled car wheels and the stresses produced during mounting and under service loads. The tests, made in cooperation with the Association of Manufacturers of Chilled Car Wheels, were confined to wheels of the standard A.R.A. single-plate pattern.

New Advances in Arc Welding Equipment Design

F. J. HIRNER. *12 pages, 8½x11 in. Published by the Welding Div., Harnischfeger Corp., 4400 W. National Ave., Milwaukee, Wis.*

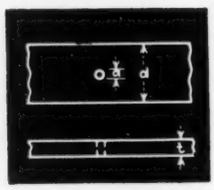
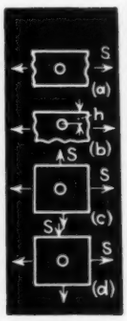
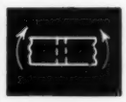
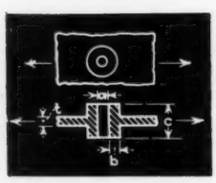
Following a brief resumé of the welding industry history, the author explains some of the complicated developments recently made in the arc welding industry. The booklet also contains an explanation of the relationship of volt ampere curves to arc heat together with tables of comparisons.

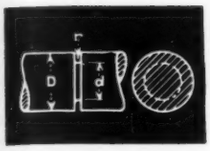
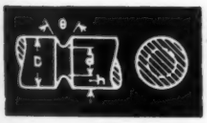
Factors of Stress Concentration

For Elastic Stress (k), Repeated Stress (k_f), and Rupture (k_r)

RAYMOND J. ROARK
Professor of Mechanics, University of Wisconsin

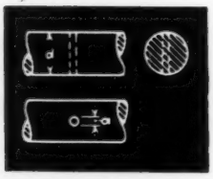
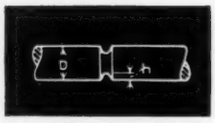
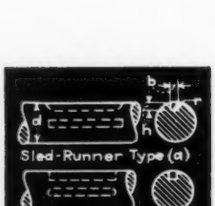
Continued from page 156, April number

TYPE OF FORM IRREGULARITY OR STRESS-RAISER	STRESS CONDITION	MANNER OF LOADING	FACTOR OF STRESS CONCENTRATION k, k_f, k_r FOR VARIOUS DIMENSIONS
 CIRCULAR HOLE IN PLATE OR RECTANGULAR BAR	*Elastic Stress*	 *Tension*	(a) Uniaxial stress, hole central $k = 3 - 3.13\frac{a}{d} + 3.76\left(\frac{a}{d}\right)^2 - 1.71\left(\frac{a}{d}\right)^3$ (empirical formula, **Ref. 22**) $k = \frac{3d}{d+a}$ (approximate formula, **Ref. 20**) (b) Uniaxial stress, hole near edge of wide plate $h/a =$ 0.67 0.77 0.91 1.07 1.29 1.56 $k =$ 4.37 3.92 3.61 3.40 3.25 3.16 **Ref. 21** (c) Biaxial stress, a/d small $k = 2$ (d) Biaxial stress, a/d small $k = 4$
		 *Bending*	Approximately same as for tension.
	Repeated Stress	*Tension*	$d = 1.50$ $t = 0.064$ $a = 0.0365$ to 0.20 Cold rolled hard steel strip 1.4 per cent ultimate elongation $k_f = 2.15$ **Ref. 26)**
		Bending	$d = \frac{1}{2}$ $t = 0.05$ $a = 0.055$ Material — k_f 1.20 per cent C. Steel (normalized) — 1.25 0.52 per cent C. Steel (normalized) — 1.31 0.37 per cent C. Steel (normalized) — 1.22 Cr. Ni. Steel (3 heat treatments) — 1.30, 1.53, 1.76 3.5 per cent Ni. Steel (2 heat treatments) — 1.31, 1.38 Armco Iron (0.02 per cent C.) — 1.30 0.49 per cent C. Steel — 1.12 **Ref. 17**
	Static Rupture	*Bending*	Beams, $d = 1$ $t = 1\frac{1}{2}$ — $a = \frac{1}{16}$ $a = \frac{1}{2}$ Plaster 1.33 1.43 Cast Iron 1.03 1.11 Circular Flat Plate, diameter = 8.4, $t = 0.375$, — $a = \frac{1}{4}$ $a = \frac{1}{2}$ Plaster 1.5 —— Cast Iron —— 1.19 **Ref. 12**
 CIRCULAR HOLE WITH BEAD IN WIDE PLATE	*Elastic Stress*	*Tension*	(Bead area) $A_b = b(c - t)$ (Hole area) $A_h = at$ $A_b/A_h =$ 0.1 0.2 0.3 0.4 0.5 $k =$ 2.53 2.17 1.90 1.69 1.53 **Ref. 5**

TYPE OF FORM IRREGULARITY OR STRESS-RAISER	STRESS CONDITION	MANNER OF LOADING	FACTOR OF STRESS CONCENTRATION k, k_f, k_r, FOR VARIOUS DIMENSIONS
 U NOTCH IN CIRCULAR SHAFT	*Elastic Stress*	*Tension*	Approximately same as case of square shoulder with fillet in rectangular bar **Ref. 1**
		Bending	Approximately same as case of square shoulder with fillet in rectangular bar **Ref. 1**
		Torsion	$k=\dfrac{(D-d+2r)(d+2r)^2+4r^2(D-d-2r)}{2rD(d+4r)}$ For semicircular notch ($d=D-2r$) $k=\dfrac{2D}{D+2r}$ **Ref. 2, 3**
	Repeated Stress	*Bending*	Material / D / h / r / k_f 6130 Steel, 0.29 per cent C. (H. T.) — 0.48 — 0.015 — 0.015 — 2.20 6130 Steel, 0.29 per cent C. (H. T.) — 0.716 — 0.156 — 0.125 — 1.37 0.10 per cent C. Steel — 0.3 — 0.008 — 0.002 — 1.21 0.10 per cent C. Steel — 0.6 — 0.008 — 0.002 — 1.07 **Ref. 14** 0.62 per cent C. Steel — 0.34 — 0.012 — 0.006 — 1.78 Cr. Ni. Steel (3.5 per cent Ni., 0.8 per cent Cr. (H. T.)) — 0.60 — 0.008 — 0.002 — 2.00 0.2 per cent C. Cast Steel, annealed — 0.30 — 0.008 — 0.002 — 1.31 **Ref. 10**
	Static Rupture	*Tension*	Material / D / h / r / kr Cast Iron — 0.6 — 0.052 — 0.03 — 1.01 Cast Iron — 0.4 — 0.035 — 0.02 — 1.18 Nickel Cast Iron — 0.6 — 0.052 — 0.03 — 1.06 Nickel Cast Iron — 0.4 — 0.035 — 0.02 — 1.01 Cast Magnesium — 0.475 — 0.04 — 0.02 — 1.16 Al. 112 — 0.35 — 0.035 — 0.02 — 1.24 Al. 195 — 0.35 — 0.035 — 0.02 — 0.81 Al. 220 — 0.35 — 0.035 — 0.02 — 0.76 **Ref. 12**
 V NOTCH IN CIRCULAR SHAFT	*Elastic Stress*	*Tension*	r/d = 0.05 0.10 0.15 0.20 0.30 0.40 0.50 k = 3.4 2.5 2.1 1.9 1.62 1.5 1.4 **Ref. 1, 4**
		Bending	r/d = 0.05 0.10 0.15 0.20 0.30 0.40 0.50 k = 2.55 2.0 1.74 1.6 1.43 1.31 1.25 **Ref. 1, 4** For h/d small, $k=(1+2\sqrt{h/r})\,/\,(1+\sqrt{h/r})$ times value given below for k in torsion **Ref. 8**
		Torsion	Value of h/r θ — 0.5 — 1 — 3 — 5 — 9 0 deg. — 1.85 — 2.01 — 2.66 — 3.23 — 4.54 60 deg. — 1.84 — 2.00 — 2.54 — 3.06 — 3.90 90 deg. — 1.81 — 1.95 — 2.40 — 2.64 — 3.12 120 deg. — 1.66 — 1.75 — 1.95 — 2.06 — 2.13 **Ref. 8**
	Repeated Stress	*Bending*	Material / θ / Value of h/r: 1, 4, 7, ∞ 0.33 per cent C. Steel — 72° — 1.16 — 1.31 — 1.42 — ($h<0.0025$) 0.33 per cent C. Steel — 63½° — 1.45 — 1.90 — 2.20 — ($h=0.005$ to 0.045) } $D=0.45$ **Ref. 8** Normalized Ext. Mag. Al. Alloy — 60° — — — 1.50 — — 1050 Steel (H.T.) — 60° — — — 2.37 — — 6130 (.29 per cent C.) Steel (H.T.) — 60° — — — 2.62 — — ($h=0.036$ to 0.040 $D=0.5$) **Ref. 14** 25s Al. — 60° — — — 1.80 — — Cast Al. 220 — 72° — — — — — 0.69 Cast Iron — 72° — — — — — 0.90 ($h=0.05$, $D=0.40$) **Ref. 12** Ext. Al. 17 ST. — 60° — 1.67 — — — **Ref. 15**
	Static Rupture	*Tension*	$\theta=72$ deg. $h/D=0.87$ Material / Value of h/r: ∞, 1.72 Cast iron — 1.10 — 1.10 Ni. cast iron — 1.05 — 1.04 Al. 112 — 1.09 — 1.24 Al. 195 — 0.82 — 0.81 Al. 220 — 0.81 — 0.76 Mag. — 1.23 — 1.16 **Ref. 12**

REFERENCES

9. Peterson, R. E. "Model Testing as Applied to Strength of Materials," Am. Soc. Mechanical Engrs., *Jour. Applied Mechanics*, Vol. 1 No. 2, Paper APM 55–11, 1933.
11. Trinks W. and Hitchcock, "Strength of Roll Necks," *Trans.* Amer. Soc. Mechanical Engrs., Vol. 55, p. 67, 1933.
14. Moore, R. R. "Effect of Grooves, Threads and Corrosion upon the Fatigue of Metals," *Proc.* Am. Soc. Testing Materials, Vol. 26, Part II, p. 255, 1926.
15. Templin, R. L. "The Fatigue Properties of Light Metals and Alloys," *Proc.* Am. Soc. Testing Materials, Vol. 33, Part II, p. 364, 1933.
16. Moore, H. F., Lyons, S. W. and Inglis, N. P. "Tests of the Fatigue Strength of Cast Iron," *Bulletin* 164, Eng. Exp. Station, Univ. of Illinois, 1927.
18. Gough, H. F. "The Effect of Keyways upon the Strength and Stiffness of Shafts Subjected to Torsional Stresses." *British Aero. Research Committee Reports*, Vol. II, p. 488, 1924–25.
19. Moore, H. F., "The Effect of Keyways on the Strength of Shafts," *Bulletin* 42, Eng. Exp. Station, Univ. of Illinois, 1910.
21. Jeffrey, J. B. "Plane Stress and Plane Strain in Bipolar Coordinates," *Philosophical Proc.* Royal Soc. of London, A-Vol. 221, p. 265, 1921.
23. Peterson, R. E., "Fatigue of Shafts Having Keyways," *Proc.* Am. Soc. Testing Materials, Vol. 32, Part II, p. 413, 1932.
26. Haigh. Report of Committee on Complex Stress Distribution, *Reports*—British Association for Advancement of Science, 1922-23-24.

TYPE OF FORM IRREGULARITY OR STRESS-RAISER	STRESS CONDITION	MANNER OF LOADING	FACTOR OF STRESS CONCENTRATION k, k_f, k_r, FOR VARIOUS DIMENSIONS
 RADIAL HOLE IN CIRCULAR SHAFT	*Elastic Stress*	*Tension*	Approximately same as for circular hole in plate
		Bending	Approximately same as for circular hole in plate
		Torsion	For a/d very small, $k = 4$
	Repeated Stress	*Bending*	Value of d: 0.10 / 0.273 / 0.30 / 0.35 / 0.50 / 1 / 2.13 / 3 0.45 per cent C. Steel, a/d 0.0625: — / — / — / — / 1.34 / 1.55 / — / 1.88 0.45 per cent C. Steel, a/d 0.250: 1.1 / — / — / — / 1.36 / 1.40 / — / 1.55 — **Ref. 9** 0.57 per cent C. Steel (H.T.), a/d 0.150: — / 1.40 / — / — / — / — / 2.22 / — Armco Iron, a/d 0.183: — / — / 1.38 / — / — / — / — / — 0.49 per cent C. Steel (H.T.), a/d 0.183: — / — / 1.27 / — / — / — / — / — 0.52 per cent C. Steel (H.T.), a/d 0.183: — / — / 1.34 / — / — / — / — / — **Ref.17,10** Cyclops metal (annealed), a/d 0.183: — / — / 1.05 / — / — / — / — / — Cast Iron, a/d 0.157: — / — / — / 1.15 / — / — / — / — **Ref.16,10**
	Static Rupture	*Bending*	Material — a/d — Value of d: 2 — 3 Plaster — 0.0625 — 1.84 — 1.65 Plaster — 0.125 — 1.50 — 1.70 Plaster — 0.250 — 1.37 — 1.46 — **Ref. 13**
		Torsion	Material — a/d — Value of d: 2 — 0.82 — 0.5 — 0.331 Plaster — 0.0625 — 1.86 — — — — } **Ref. 13** Plaster — 0.125 — 1.89 — — — — Plaster — 0.250 — 2.12 — — — — Plaster — 0.076 — — 1.17 — — Cast Iron — 0.125 — — — 1.22 — Ni. Cast Iron — 0.125 — — — 1.11 — } **Ref. 12** Al. 112 — 0.125 — — — — 1.14 Al. 195 — 0.125 — — — — 1.06 Al. 220 — 0.125 — — — — 1.05
 SCREW THREAD	*Repeated Stress*	*Tension*	$D = 0.375$, Whitworth V-thread, 16 threads to inch Material — k_f 0.065 per cent C. Steel — 1.35 0.331 per cent C. Steel — 1.41 0.446 per cent C. Steel — 1.51 0.645 per cent C. Steel — 1.45 — **Ref. 25**
		Bending	Material — $D = \frac{1}{2}$ inch, $h = 0.0232$ inch, 28 threads to inch: Continuous thread / single notch — $D = \frac{1}{4}$ inch, $h = 0.0271$ inch, 24 threads to inch: Continuous thread / single notch Tie rod steel 0.43 per cent C. — 1.18 / 4.25 — 1.38 / 2.42 — **Ref. 14**
 KEYWAY IN CIRCULAR SHAFT	*Elastic Stress*	*Torsion*	For r = o, theoretical $k = \infty$. Tests to determine elastic failure gave $k = 1.30$ — **Ref. 18, 19**
	Repeated Stress	*Bending*	Material — Type (a) — Type (b) Cr. Ni. Steel (H.T.) — 1.35 — 1.74 Medium C. Steel, (normalized) — 1.11 — 1.35 — **Ref. 23**
		Torsion	Type (b), $d = 0.4$, $h = 0.036$ Material — b = 0.109 — b = 0.055 0.65 per cent C. Steel — 1.27 — 1.27 Armco Iron — 1.14 — 1.14 — **Ref. 18**
	Static Rupture	*Bending*	Type (a) — Type (b) Plaster — 1.08 — 1.28 — **Ref. 12, 13**
		Torsion	Type (a) — Type (b) Plaster — 1.44—1.29 — 1.68 Cast Iron — 1.17 — —— — **Ref. 12, 13**